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[*Authors alone are responsible for all opinions expressed in their Communications.*]

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No. 35.

REPORT OF THE IRISH RADIUM COMMITTEE FOR THE YEAR 1935.

[Read MAY 26. Published separately JULY 20, 1936.]

THE tendency towards the use of smaller doses noted in previous reports has been replaced by a movement in the opposite direction; thus, during 1935 16,581 millicuries of radon were issued in 2,540 capillaries—an average of 6·5 mc. per capillary, as compared with 11,744 mc. in 2,312 capillaries, an average of 5·1 per capillary in 1934. The number of millicuries issued per case has risen from 19·9 in 1934 to 27·6 in 1935.

No important changes have been made in the technique of preparation of the tubes during the year. Mr. G. M. FitzGerald and Mr. H. J. Walker were appointed to the Radium Exhibitions falling vacant during the year.

Reports from some of the largest users of radon are printed below. In addition to these the following returns have been received of numbers of cases treated with radon, either alone or in conjunction with surgery or X-rays:—

Central Hospital, Galway	28 cases.
St. John's Hospital, Limerick	6 „
Rotunda Hospital	5 „
St. Ultan's Hospital	2 „

The total number of cases of which reports have been received is—

Malignant	451
Non-malignant	149
Total, ...	600

This may be compared with 441 malignant cases, and 149 non-malignant cases—total, 590—reported during 1934.

REPORT FROM ST. ANNE'S HOSPITAL.

Radiologist—DR. OLIVER CHANCE.

The total number of new malignant cases admitted to St. Anne's Hospital in 1935 was 368, an increase of 71 per cent. over 1934. The number of cases re-admitted for observation rose from 85 to 122. These figures are a striking illustration of the increase in work which has occurred in the hospital. As the number of beds available and the facilities have not altered, it is now clear that if improvements are not made in the near future the efficiency of the hospital must suffer. Already there is a small waiting list of patients desiring admission.

It was pointed out in last year's report that roughly 25 per cent. of patients failed to report either in person or in writing. This year, if those uterine cases which were referred from other hospitals for prophylactic treatment

and "followed-up" by them are ignored, the percentage of untraced cases is only 7 per cent. While this figure is still considerably higher than in most continental clinics, the improvement over last year is cause for self-congratulation, and evidence of the keenness and trouble with which the work in the hospital is carried out under exceptionally difficult circumstances.

Beyond minor alterations few changes have been made in technique. The appointment of a dental surgeon, who attends hospital regularly, has resulted in moulds being used to a much greater extent than formerly. In X-ray technique, while very big total doses are given, the pressure of work does not permit a low intensity technique such as is commonly used at the moment.

Malignant Cases, 1935.

New Cases. All Types.

1. No. of cases of all types of malignant diseases seen 1935, 368.
2. No. of cases of all types of malignant diseases treated 1935, 315.
3. No. of cases of all types of malignant diseases treated by Surgery alone, 26.
4. No. of cases of all types of malignant diseases treated by Radium alone, 134.
5. No. of cases of all types of malignant diseases treated by Deep X-rays alone, 64.
6. No. of cases of all types of malignant diseases treated by Surgery and Radium, 20.
7. No. of cases of all types of malignant diseases treated by Surgery and X-rays, 51.
8. No. of cases of all types of malignant diseases treated by Radium and X-rays, 15.
9. No. of cases of all types of malignant diseases treated by Radium, Surgery, and X-rays, 3.

(In 59 of the cases in which surgery and radiation were combined, operations were carried out in other hospitals, and the patients later referred to St. Anne's for radiation.)

List of Cases treated with Radium or Radon. (Total, 172.)

Malignant Cases first seen 1935.

Rodent Ulcer	33	Carcinoma of Tonsil	1
Carcinoma of Skin	32	„ „ Breast	5
„ „ Lip	32	„ „ Vulva	1
„ „ Tongue ...	36	„ „ Cervix Uteri ...	7
„ „ Cheek	5	Sarcoma	3
„ „ Palate and Fauces	3	Melanotic Sarcoma	1
„ „ Floor of Mouth ...	8	Endothelioma	1
„ „ Gum	4		

Non-Malignant Cases, 8.

Tubercular Peritonitis ...	1	Verucae Vulgaris	1
Hodgkins' Disease	1	Cheloids	2
Angioma	3		

MALIGNANT CASES FIRST SEEN 1935.

(Including some cases treated with X-rays and Surgery.)

Rodent Ulcers, 38.

Treated with radium, 33. Treated with X-rays, 1. Well, 22. Still under treatment, 7. Unimproved, 4. Dead, 1.

Carcinoma of Skin, 42.

Treated with radium, 32. Treated with X-rays, 2. Treated with surgery, 5. Unsuitable, 3. Well, 15. Improved, 1. Unimproved, 7. Still under treatment, 6. Untraced, 10.

Buccal Carcinoma.

Cases seen, 132. Treated, 112. Unsuitable or refused treatment, 20.

	No. of Cases.	Well.	Primary well, but glands involved.	Imp.	Untraced.	Unimp.	Still under tr.	Dead.
Carcinoma Lip, 33.								
Group 1 ...	12	8	1	1	—	—	2	—
Group 2 ...	5	2	—	1	1	—	1	—
Group 3 ...	16	3	1	4	1	3	2	2
Carcinoma Tongue, 37.								
Group 1 ...	22	8	5	3	1	2	3	—
Group 2 ...	8	—	—	—	2	4	1	1
Group 3 ...	7	—	—	—	2	3	1	1
Carcinoma Cheek, 7.								
Group 1 ...	4	3	—	—	—	—	1	—
Group 2 ...	2	1	—	—	—	—	—	1
Group 3 ...	1	—	—	1	—	—	—	—
Carcinoma Palate, 5.								
Group 1 ...	3	1	—	2	—	—	—	—
Group 2 ...	1	—	—	—	—	—	1	—
Group 3 ...	1	—	—	—	1	—	—	—
Carcinoma Tonsil, 14.								
Group 1 ...	3	3	—	—	—	—	—	—
Group 2 ...	1	1	—	—	—	—	—	—
Group 3 ...	10	1	—	6	—	3	—	—
Carcinoma Fauces, 3.								
Group 1 ...	2	—	—	—	—	2	—	—
Group 2 ...	—	—	—	—	—	—	—	—
Group 3 ...	1	—	—	—	1	—	—	—
Carcinoma Floor of Mouth, 8.								
Group 1 ...	4	2	—	—	1	—	1	—
Group 2 ...	—	—	—	—	—	—	—	—
Group 3 ...	4	—	—	—	—	—	3	1
Carcinoma Gum, 5.								
Group 1 ...	3	—	1	—	—	2	—	—
Group 2 ...	—	—	—	—	—	—	—	—
Group 3 ...	2	—	—	—	—	1	—	1

Carcinoma of Cervix Uteri.

Cases seen, 13. Unsuitable, 3. Treated, 10. Treated with radium, 7. Treated with X-rays, 3. Improved, 3. Dead, 3. Still under treatment, 2. Untraced, 2.

Carcinoma Body of Uterus.

Cases seen, 9. Unsuitable, 1. Treated, 8. Admitted as Post-Operative cases for Prophylactic X-rays, 7. Well, 2. Untraced, 5. Treated with surgery, 1. Well, 1.

Carcinoma Vulva.

Cases seen, 5. Treated with surgery and radium, 1. Well, 1. Treated with X-rays, 1. Transferred for further treatment, 1. Unsuitable, 3.

Carcinoma Breast, 29.

Treated, 25. Unsuitable, 4.

	No. of Cases.	Well.	Imp.	Unimp.	Under treatment.	Untraced.	Dead.
Surgery ...	3	3	—	—	—	—	—
Pre-Op. X-rays ...	2	—	—	—	—	—	—
Post-Op. Prophylactic X-rays ...	2	2	—	—	—	—	—
Palliative X-rays	6	—	—	4	—	2	—
Post-Operative Recurrence ...	7	3	—	1	1	2	—
Primary Irradiation Radium ...	5	1	—	2	2	—	—

Carcinoma Thyroid, 2.

Treated with X-rays and surgery, 1. Well, 1. Treated with X-rays, 1. Untraced, 1.

Carcinoma Paratid, 3.

Unsuitable, 3.

Carcinoma Anus, 1.

Refused treatment, 1.

Carcinoma Bladder, 1.

Treated with surgery, 1. Unimproved, 1.

Carcinoma Penis, 3.

Treated with surgery and X-rays, 3. Untraced, 3.

Carcinoma Prostate, 1.

Treated with X-rays, 1. Untraced, 1.

Carcinoma Rectum, 16.

Unsuitable, 1. Treated with surgery, 14. Temporarily relieved, 5. Untraced, 8. Dead, 2. Treated with surgery and X-rays, 1. Temporarily relieved, 1.

Branchial Carcinoma, 2.
Treated with X-rays, 2. Well, 1. Dead, 1.

Primary Carcinoma, Glands of Neck, 8.
Treated with X-rays, 8. Well, 2. Still under treatment, 2. Unimproved, 2. Dead, 2.

Carcinoma of Maxillary Antrum, 3.
Unsuitable, 1. Treated with surgery and X-rays, 2. Well, 1. Improved, 1.

Carcinoma of Epiglottis, 3.
Treated with X-rays, 2. Still under treatment, 2. Unsuitable, 1.

Carcinoma of Larynx (Intrinsic), 9.
Treated with X-rays, 9. Well, 2. Improved, 3. Still under treatment, 1. Untraced, 1. Dead, 2.

Extrinsic Carcinoma Larynx, 6.
Treated with X-rays, 6. Well, 1. Still under treatment, 1. Dead, 4.

Carcinoma of Naso-Pharynx, 2.
Treated with X-rays, 2. Unimproved, 2.

Carcinoma of Oesophagus, 9.
Unsuitable, 6. Treated with surgery, 2. Temporarily relieved, 1. Died, 1. Treated with X-rays, 1. Improved, 1.

Carcinoma of Stomach, 2.
Unsuitable, 2.

Carcinoma of Appendix, 1.
Post-Operative Prophylactic X-rays, 1. Unimproved, 1.

Malignant Ovarian Cyst, 2.
Treated with X-rays, 1. Untraced, 1. Treated with surgery and X-rays, 1. Well, 1.

Mediastinal Tumour, 1.
Treated with X-rays, 1. Untraced, 1.

Pituitary Tumour, 1.
Treated with X-rays, 1. Untraced, 1.

Glioma of Retina, 1.
Treated with surgery and X-rays, 1. Unimproved, 1.

Hypernephroma, 1.
Treated with X-rays, 1. Unimproved, 1.

Parasaggital Tumour, 1.
Treated with surgery and X-rays, 1. Unimproved, 1.

Endothelioma of Palate, 1.
Treated with surgery and X-rays, 1. Well, 1.

Sarcoma of Thigh, 2.
Treated with surgery and X-rays, 1. Improved, 1. Treated with X-rays, 1. Unimproved, 1.

Sarcoma of Mediastinum, 1.
Treated with X-rays, 1. Untraced, 1.

Retro-Peritoneal Sarcoma, 1.
Treated with X-rays, 1. Still under treatment, 1.

Sarcoma of Antrum, 1.
Treated with X-rays and radium, 1. Untraced, 1.

Sarcoma of Orbit, 1.
Treated with surgery and radium, 1. Still under treatment, 1.

Sarcoma of Leg, 1.
Treated with X-rays, 1. Unimproved, 1.

Sarcoma of Upper Arm, 2.
Treated with X-rays, 2. Unimproved, 2.

Sarcoma of Naso-Pharynx, 1.
Treated with X-rays, 1. Died, 1.

Sarcoma of Lungs, 1.
Treated with X-rays, 1. Died, 1.

Sarcoma of Cervix, 1.

Sarcoma of Uterus, 1.
Treated with surgery, radium, and X-rays, 1. Still under treatment, 1.

Sarcoma of Jaw, 1.
Treated with radium, 1. Still under treatment, 1.

Lympho-Sarcoma of Tonsil, 1.
Treated with surgery and X-rays, 1. Well, 1.

Lympho-Sarcoma Glands of Neck, 1.
Treated with X-rays, 1. Unimproved, 1.

Melanotic Sarcoma of Lip, 1.
Treated with radium and surgery, 1. Still under treatment, 1.

Melanotic Sarcoma Cheek, 1.
Refused treatment, 1.

Report by Oliver Chance, M.B., B.Ch., D.M.R.E.,

Richmond, Sir P. Dun's, Dr. Steevens', and Coombe Hospitals.

In 1935 forty-four cases less were treated with radium and radon than in the previous year. The decrease is due to the fact that many cases were referred from the above hospitals to St. Anne's Hospital, which possesses special facilities for radiological treatment. Elsewhere in this report it will be seen

that there was a considerable increase over previous years in the number of cases treated in that hospital.

In spite of spending considerable time and trouble in the "follow-up" of cases, no less than thirty out of one hundred and sixty-seven were not traced.

No radical changes in radium technique were made during the year; in X-ray treatment the tendency has been to increase protraction of dose, so that now up to 5,000 r. is given to the skin over a period of seven weeks.

Owing to unforeseen circumstances it has not been possible to produce statistics for the cases treated in previous years such as were published in the report for 1934.

List of Cases treated with Radium or Radon. (Total, 167.)

Malignant Cases, 124.

Rodent Ulcers	40	Carcinoma of Cervix Uteri ...	19
Carcinoma of Skin	15	„ „ Body of Uterus ...	1
„ „ Lip	14	„ „ Breast	2
„ „ Tongue ...	14	Recurrent Carcinoma of Breast	5
„ „ Cheek	1	Tumour of Parotid	2
„ „ Palate	2	Seminomata	1
„ „ Floor of Mouth ...	3	Carcinoma of Thyroid ...	2
„ „ Gum	3		

Non-Malignant Cases, 43.

Tubercular Peritonitis ...	19	Naevus	1
Toxic Goitre	6	Hairy Mole	1
Painful Scars	1	Actinomycosis	1
Warts	5	Fibrosis Uteri	3
Keloids	4	Menorrhagia	2

Malignant Cases.

(Including also some cases treated with X-rays, etc.)

Rodent Ulcers, 45.

Treated by surgery, 4. Unsuitable, 1. Treated with radium, 40. Well, 33. Improved, 1. Unimproved, 1. Still under treatment, 3. Untraced, 2.

Carcinoma of Skin, 24.

Treated by surgery, 2. Unsuitable, 7. Treated with radium, 15. Well, 10. Unimproved, 1. Still under treatment, 3. Untraced, 1.

Buccal Carcinoma, 37.

Cases seen, 54. Treated, 37. Unsuitable, 17.

	No. of cases.	Well.	Primary well, but glands involved.	Unimpr.	Untrcd.	Still under treatment.	Dead.
Carcinoma Lip, 14.							
Group 1 ...	10	6	1	—	3	—	—
Group 2 ...	2	1	—	—	1	—	—
Group 3 ...	2	—	2	—	—	—	—
Carcinoma Tongue, 14.							
Group 1 ...	11	6	2	1	1	—	1
Group 2 ...	3	—	1	1	—	—	1
Carcinoma Cheek, 1.							
Group 1 ...	1	1	—	—	—	—	—
Carcinoma Palate, 2.							
Group 1 ...	2	1	—	—	—	—	1
Carcinoma Floor of Mouth, 3.							
Group 1 ...	2	1	—	—	—	—	1
Group 2 ...	1	—	—	—	—	—	1
Carcinoma Gum, 3.							
Group 1 ...	1	1	—	—	—	—	—
Group 2 ...	2	1	1	—	—	—	—

Tumours of the Tonsil, 8.

(*a*) *Carcinoma*, 5.

Group 1. Treated with X-rays, 2. Well, 2.

Group 3. Treated with X-rays, 3. Well, 1. Unimproved, 1. Dead, 1.

(*b*) *Lympho-Sarcoma*, 2.

Group 1. Treated with X-rays, 1. Well, 1.

Group 2. Treated with X-rays, 1. Well, 1.

(*c*) *Lympho-Epithelioma*, 1.

Group 3. Treated with X-rays, 1. Dead, 1.

Epiglottis, 1.

Treated with X-rays, 1. Improved, 1.

Carcinoma Larynx, 7.

(*a*) *Intrinsic*, 3. Treated with X-rays, 3. Well, 1. Dead, 1.

(*b*) *Extrinsic*, 4. Treated with X-rays, 4. Well, 1. Improved, 2. Dead, 1.

Carcinoma Maxilla, 4.

Treated with X-rays, 4. Apparently clear, 2. Unimproved, 1. Dead, 1.

Carcinoma Cervix Uteri.

Cases seen, 23. Unsuitable, 4. Treated with radium, 19.

	No. of cases.	Well.	Improved, but disease still active.	Unimproved.	Untraced.	Dead.
Operable ...	4	3	—	—	1	—
Borderline ...	3	2	—	—	1	—
Inoperable ...	12	4	2	1	4	1

Carcinoma Body of Uterus, 3.

Treated with radium, 1. Well, 1. Treated with X-rays and surgery, 2. Well, 2.

Carcinoma Mammae, 11.

(*a*) *Stage 1.* 7. Treated by surgery and X-rays, 5. Treated with radium, 2. Well, 5. Disease still active, 1. Still under treatment, 1.

(*b*) *Stage 2.* 1. Treated with X-rays and surgery, 1. Well, 1.

(*c*) *Stage 3.* 3. Treated with X-rays, 3. Disease still active, 3.

Recurrent Carcinoma Breast, 8.

Treated with radium, 3. Dead, 2. Disease still active, 1. Treated with X-rays and radium, 2. Dead, 1. Untraced, 1. Unsuitable, 3.

Mixed-Celled Tumour of Parotid, 2.

Treated with radium, 2. Well, 1. Untraced, 1.

Brain Tumour, 1.

Treated, 1. Untraced, 1.

Carcinoma Oesophagus, 1.

Treated, 1. Dead, 1.

Carcinoma Thyroid, 2.

Treated, 2. Well, 1. Dead, 1.

Carcinoma Ovary, 2.

Treated with X-rays, 2. Improved, 2.

Hyper-Nephroma, 1.

Treated with X-rays, 1. Dead, 1.

Seminomata, 1.

Treated by surgery and radium, 1. Well, 1.

Carcinoma Prostate, 2.

Treated with X-rays, 2. Improved, 2.

Carcinoma Scrotum, 1.

Unsuitable, 1.

Bone Sarcomas, 7.

Unsuitable, 2. Treated with X-rays, 5. Improved, 3. Unimproved, 1. Dead, 1.

Carcinoma Rectum, 3.
Operable—Referred for surgery, 2.
Inoperable—Palliative X-rays, 3. Improved, 2. Untraced, 1.
Unsuitable, 2.

Malignant Glands Neck (no primary found), 3.
Treated with X-rays, 3. Improved, 3.

Non-Malignant Cases.

(Including also some cases treated with X-rays.)

Tubercular Peritonitis, 19.
Treated with radium, 19. Well, 6. Improved, 3. Unimproved, 1. Untraced, 9.

Toxic Goitre, 6.
Well, 1. Greatly improved, 4. Untraced, 1.

Adenoma Prostate, 2.
Treated with X-rays, 2. Well, 1. Unimproved, 1.

Painful Scars, 1.
Treated, 1. Improved, 1.

Warts, 5.
Treated, 5. Well, 5.

Keloids, 4.
Treated, 4. Improved, 3. Untraced, 1.

Naevus, 1.
Treated with radium, 1. Improved, 1.

Hairy Mole, 1.
Treated with radium, 1. Improved, 1.

Actinomycosis, 1.
Treated, 1. Well, 1.

Sciatica, 1.
Treated with X-rays, 1. Improved, 1.

Osteo-Arthritis, 2.
Treated with X-rays, 2. Improved, 2.

Fibrosis Uteri, 3.
Treated, 3. Well, 2. Untraced, 1.

Pruritis Vulvae, 1.
Treated with X-rays, 1. Improved, 1.

Menorrhagia, 2.
Treated, 2. Well, 2.

Return furnished by Dr. Oswald J. Murphy, St. Vincent's Hospital.

Cases seen and treated during 1935.

Malignant cases.	Seen.	Treated.
Carcinoma of the Ear ...	4	4
„ of the Lip ...	8	8
„ of the Cheek ...	4	4
„ of the Tongue ...	12	9
„ of Floor of Mouth	3	3
„ Secondary glands in Neck ...	5	5
„ of the Palate ...	2	2
„ Tonsil ...	4	3
„ Pharynx ...	3	2
„ Larynx ...	1	1
„ Oesophagus ...	1	0
„ Paratid ...	1	1
„ Breast ...	6	5
„ Breast Secondaries	7	7
„ Penis	1	0
„ Anus	2	2
„ Uterine cervix ...	5	5
„ Uterine body ...	3	2
„ Skin surfaces ...	20	20
Rodent Ulcers	31	31
Sarcoma of Maxillary Antrum	2	2
	125	116

Non-Malignant.	
Goitre	4
Hodgkin	7
T.B. Cervical glands	8
T.B. Peritonitis	6
Uterine Hæmorrhages	6
Angiomata	19
Lupus Vulgaris	3
Lupus Erythematosus	2
Keloids	5
Warts	26
Corns	4
Hypertrichosis	6
	96

Malignant Cases.

Carcinoma of the Ear, 4.

		Apparently well.	Improved.	Unimproved.	Died.
No palpable glands ...	3	1	2	0	0
Palpable glands ...	1	0	1	0	0

Three were early cases with no involvement of cartilage. Surface applications from a distance of 1 cm. lasting 6–8 days sufficed for 3 cases. Three applications were necessary in one patient. Case No. 4 had considerable involvement of the cartilage—6 weeks after irradiation the diseased cartilage was removed surgically.

Carcinoma of the Lip, 8.

		Apparently well.	Improved.	Unimproved.	Died.
No palpable glands ...	5	2	3	0	0
Palpable glands ...	3	1	2	0	0

Palpable glands were surgically removed 4–6 weeks after radium treatment. In one patient, an elderly man with extensive ulceration and glands, it was interesting to note that the glands were tuberculous, showing only in one small area malignant change.

Carcinoma of the Cheek, 4.

No glands palpable, as all were early cases and all are doing well.

Carcinoma of the Palate, 2.

No glands palpable—applicators fitted in all cases. In one case there is a perforation into the nasal cavity.

Carcinoma of the Tonsil, 3.

No palpable glands—1. This case is improving.

Palpable glands—2. One has improved, and one has died.

Carcinoma of the Pharynx—2; *and Larynx*—1.—All had large masses of glands. One Pharyngeal and the Laryngeal case has died.

Carcinoma of Parotid—1.—Growth was removed surgically and radium from a distance of 2 cm. applied later.

Carcinoma of the Tongue, 9.

		Apparently well.	Improved.	Unimproved.	Died.
No palpable glands ...	1	1	0	0	0
Palpable glands ...	8	3	3	1	1

In addition to the above cases, 5 cases were treated by radium which previously had had the primary growths removed in the country. Of the 9 cases 3 were in the anterior third, 4 in the middle third, and 2 in the posterior third. Only one case arrived in an early stage.

Carcinoma of the Floor of the Mouth, 3.

One was very advanced emaciated and only palliative local irradiation—he has since died.

Carcinoma of the Breast, including Secondaries, 12.

Four cases received wide surface applications following surgical removal of breast. One case with a large fungatory mass was treated by radium alone, and the patient is apparently free from trouble.

The remaining 7 cases were recurrences.

Carcinoma of the Penis, 1.

This patient was in a bad way and has disappeared since treatment—presumed dead.

Carcinoma of the Anus, 2.

These growths—papillomatous—were very radio-sensitive and disappeared rapidly.

Carcinoma of the Cervix Uteri, 5.

		Apparently well.	Improved.	Unimproved.	Died.
Operable ...	2	1	1	0	0
Borderline ...	1	0	1	0	0
Inoperable ...	2	0	1	0	1

Carcinoma of Uterine Body, 3.

Operable ...	2	1	1	0	0
Inoperable ...	1	1	0	0	1

One case of carcinoma of the cervix died after 6 months—the growth was an adeno carcinoma. In both cases where the uterine body was the site involved the patients refused operation.

Carcinoma of Skin Surfaces, 20.

Apparently well.	Improved.	Unimproved.	Died.
12	4	2	0

Two cases have been lost sight of.

Rodent Ulcers, 31.

Two cases are proving very resistant to treatment.

Sarcoma of the Maxillary Antrum, 2.

Both I believe have died.

Summary of some Malignant Diseases treated during the Years 1930–1935, inclusive.

Carcinoma of the Ear.

			Alive after 1	2	3	4	5	6 years.
1930	3	...	2	2	1	1	1	1
1931	0	...	–	–	–	–	–	–
1932	0	...	–	–	–	–	–	–
1933	2	...	2	1	1	–	–	–
1934	4	...	3	3				
1935	4	...	2					
Total,	13							

Carcinoma of Cheek.

			Alive after 1	2	3 years.
1933	4	...	4	3	3
1934	6	...	5	5	
1935	4	...	1		
Total,	14				

Carcinoma of Tongue.

			Alive after 1	2	3	4	5	6 years.
1930	5	...	3	2	1	1	0	0
1931	4	...	2	1	1	1	0	
1932	8	...	4	3	3	2		
1933	3	...	2	1	1			
1934	5	...	2	2				
1935	9	...	3					
Total,	34							

Carcinoma of Lip.

			Alive after 1	2	3	4	5	6 years.
1930	5	...	3	2	2	1	1	1
1931	3	...	2	2	1	1	1	
1932	7	...	5	4	4	3		
1933	6	...	5	4	4			
1934	7	...	5	5				
1935	8	...	2					
Total,	36							

Carcinoma of Palate.

			Alive after 1	2	3	4	5	6 years.
1930	2	...	1	1	1	1	0	0
1931	2	...	1	1	1	1	0	
1932	4	...	3	2	0	0		
1933	2	...	2	2	2			
1934	1	...	1	1				
1935	2	...	1					
Total,	13							

Carcinoma of Tonsil.

			Alive after 1	2	3	4	5	6 years.
1930	1	...	1	0	0	0	0	0
1931	2	...	1	1	0	0	0	
1932	3	...	2	2	1	0		
1933	2	...	1	1	1			
1934	5	...	3	2				
1935	3	...	2					
Total,	16							

Carcinoma of Larynx.

			Alive after 1	2	3	4	5	6 years.
1930	2	...	1	0	0	0	0	0
1931	2	...	0	0	0	0	0	
1932	3	...	1	1	1	0		
1933	1	...	1	0	0			
1934	1	...	1	0				
1935	1	...	1					
Total,	10							

Carcinoma of Breast (secondaries).

			Alive after 1	2	3	4	5	6 years.
1930	6	...	3	0	0	0	0	0
1931	6	...	2	1	0	0	0	
1932	0	...	–	–	–	–		
1933	11	...	2	1	1			
1934	14	...	4	1				
1935	7	...	2					
Total,	44							

Carcinoma of Pharynx.

			Alive after 1	2	3	4	5	6 years.
1930	1	...	0	0	0	0	0	0
1931	2	...	1	0	0	0	0	
1932	2	...	0	0	0	0		
1933	0	...	–	–	–			
1934	1	...	1	0				
1935	2	...	0					
Total,	8							

Carcinoma of Breast (Primary).

			Alive after 1	2	3	4	5	6 years.
1930	5	...	2	1	0	0	0	0
1931	4	...	2	1	1	1	0	
1932	0	...	–	–	–	–		
1933	2	...	1	1	0			
1934	2	...	1	1				
1935	5	...	2					
Total,	18							

Carcinoma of Cervix Uteri.

			Alive after 1	2	3	4	5	6 years.
1930	4	...	2	2	1	1	1	1
1931	3	...	1	1	1	1	1	
1932	8	...	5	4	4	3		
1933	3	...	2	2	1			
1934	3	...	3	2				
1935	5	...	3					
Total,	26							

No. 36.

THE CHEMICAL CONSTITUENTS OF LICHENS FOUND IN IRELAND.

Buellia canescens—Part 2.

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AND

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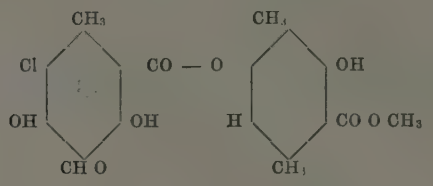
[Read February 25. Published separately July 31, 1936.]

Introduction.

In Part I of the present investigation (Nolan; Sci. Proc. R.D.S., **21**, No. 8, p. 67) the author described the isolation from the lichen *Buellia canescens* of four products, namely, diploicin, an atranorin-like product containing chlorine, mannitol, and a well-defined crystalline water-soluble organic material which did not melt. Catolechin isolated from the same lichen by Zopf (Annalen der chemie, **336**, p. 58) was shown to be an impure form of diploicin.

The present paper is concerned principally with the elucidation of the constitution of diploicin, to which in Part I were given the alternative formulae $C_{15}H_{10}O_4Cl_4$ or $C_{16}H_{10}O_5Cl_4$. However, as larger amounts of the lichen were available for this later investigation, it was possible to make a closer examination of the constituents of the lichen. The results of the earlier work have been confirmed, all four products being again isolated, but in addition a small amount of a fifth material, obviously closely related in structure to diploicin, has been isolated, and to this product we give the formula $C_{16}H_{11}O_5Cl_3$. This product is not Zopf's catolechin, as Zopf ascribes to catolechin a lower melting point than diploicin, whereas the new product melts higher than diploicin. Certain features of the earlier work require revision in view of the results that have now come to hand. For example, the atranorin-like product described in the earlier investigations was stated to contain no methoxyl, but contained 6·87 % chlorine. St. Pfau in his investigation of the lichen *Evernia prunastri* (Hel. Chim. Acta, **17**, p. 1319) described the isolation from it of an isomorphous mixture of atranorin and chloratranorin, which is very difficult to separate into its two constituents.

For chloratranorin he establishes the formula



This has been confirmed by Koller and Pöpl (Monatshefte für chemie, **64**, p. 126), who isolated the same product from *Pseudevernia furfuracea.* Chloratranorin is in fact a common constituent of lichens, for it has been isolated in the laboratories of University College, Dublin, from *Lecanora sordida* and from *Lecanora gangaleoides,* while Asahina (Ber. **68**, p. 78) isolated it from *Parmelia physodes.*

In commenting on the work published in Part I of this research St. Pfau (*loc. cit.*) says, "The product is probably a mixture of chloratranorin and atranorin. The argument advanced against such a constitution that the substance is methoxyl-free is invalidated by the fact that chloratranorin is incompletely soluble in hydriodic acid, and on that account is difficult to saponify." A similar observation regarding the difficulty in demethylating chloratranorin is made by Koller and Pöpl (*loc. cit.*, p. 127). St. Pfau's surmise is quite correct. According to Schoeller, who carried out the analysis for us, the product is not demethylated under the standard conditions of temperature, even when phenol is used as a solvent. The chloratranorin always occurs associated with unchlorinated atranorin, and it is interesting to trace a varying ratio in the two products depending on the lichen taken. For example, in *Buellia canescens,* which contains a large amount of the highly chlorinated diploicin, the atranorin is chlorinated to the extent of 90 %. In *Lecanora gangaleoides,* which contains the less highly chlorinated product gangaleoidin, the atranorin is chlorinated to the extent of 80 %, while in *Lecanora sordida,* which contains principally a non-chlorinated fatty acid, roccellic acid, and only 0·02 % of a product containing 14 % chlorine, the atranorin constituent is chlorinated to the extent of 35 %.

Our suspicions that the ordinary methods employed for methoxyl determination were not effective in the case of some at least of the chlorinated lichens' products was aroused before the remarks of St. Pfau appeared in print. On treating diploicin with ethyl alcoholic potash a product was obtained which gave carbon and hydrogen figures which could only be explained by the adding on of one molecule of ethyl alcohol, and yet the Zeisel determination showed the presence of the equivalent of two methoxyl groups (in reality one methoxyl and one ethoxyl), although analysis of the original diploicin indicated it was free from methoxyl. A determination of methoxyl in both diploicin and the suspected chloratranorin was carried out under more drastic conditions.

The substances were hydrolysed in a methylimide apparatus, and before the addition of the hydriodic acid were warmed with phenol, in which they did not completely dissolve. After distilling over the acid the formation of a precipitate in the silver solution began only after an hour's heating at 310° C. The substances are exceptionally difficult to saponify.

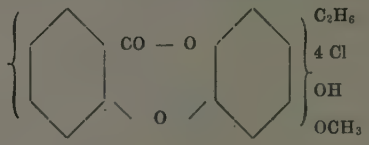
Diploicin 3·98 mg. gave 2·250 mg. AgI; methoxyl = 7·47 per cent.
Chloratranorin 3·823 mg. gave 2·340 mg. AgI; methoxyl = 8·09 per cent.

As in similar cases, estimations gave better results without any addition of a solvent; two, which were carried out in exactly the same way without phenol, give somewhat lower results.

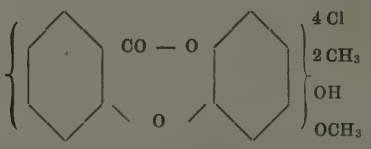
Diploicin 2·816 mg. gave 1·520 mg. AgI; methoxyl = 7·13 per cent.
Chloratranorin 3·708 mg. gave 2·230 mg. AgI; methoxyl = 7·95 per cent.
Diploicin $C_{16}H_{10}O_5Cl_4$ requires methoxyl = 7·3 per cent.
Atranorin $C_{18}H_{18}O_8$ (90 % chlorinated) requires methoxyl = 7·9 per cent.

In the earlier communication (Part I) the alternative formulae $C_{15}H_{10}O_4Cl_4$ and $C_{16}H_{10}O_5Cl_4$ were put forward for diploicin. All the experimental work recorded in the present investigation supports the latter formula, which may be accepted as correct, and is supported by the analogous constitution put forward for gangaleoidin (Nolan, Keane, and Hardiman; Sci. Proc., R.D.S., **21**, No. 14, p. 141). Since this product contains one methoxyl group it may be written $C_{15}H_7O_4Cl_4(OCH_3)$. As diploicin does not dissolve in potash, and forms an acetyl derivative, it was at first considered that an aliphatic hydroxyl group was present. However, it readily forms with diazo-methane a substance which contains two methoxyl groups, and furthermore it has been found that on treating a solution of diploicin in chloroform or benzene with dilute potash or soda an insoluble potassium or sodium salt is precipitated. These facts indicate the presence of an aromatic hydroxyl group. Aldehyde groups are absent, as no anilide is readily formed. The formula can now be written $C_{15}H_6O_3Cl_4(OH)(OCH_3)$. On treatment with methyl alcoholic potash one molecule of methyl alcohol is added on, and the resulting product is soluble in caustic potash or soda, but insoluble in sodium carbonate or bicarbonate. This indicates that diploicin contains a lactone grouping, and that the hydroxyl produced on opening the lactone bridge is aromatic. This is confirmed by the fact that on treating the opened product with diazo-methane the resulting compound contains *four* methoxyl groups. The formula may now be written $C_{14}H_6O\,Cl_4(CO.O)(OH)(OCH_3)$. General considerations of this formula, and lack of reactivity of the remaining oxygen, indicate the presence of two aromatic groups joined together by an oxygen bridge. Since the chlorine atoms are not affected on boiling diploicin with acetic anhydride and sodium acetate, or by warm alcoholic potash, the chlorine atoms cannot be in an aliphatic side chain, but must be directly attached to the benzene rings. The

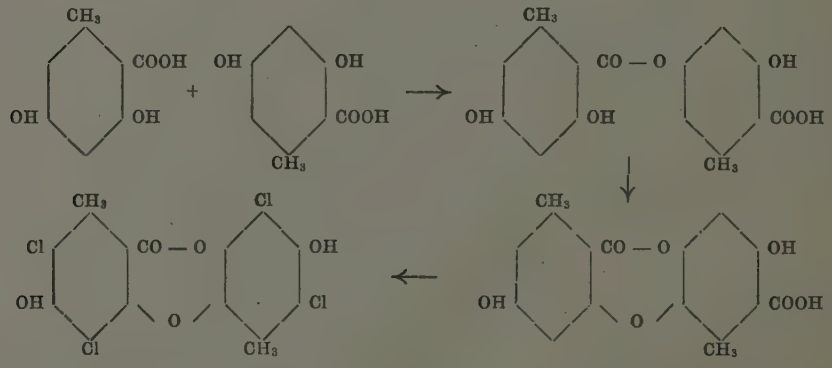
presence of four chlorine atoms indicates, as a most probable distribution, two in each ring. We thus arrive at the formula



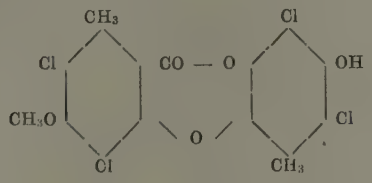
There remain but two positions in the rings to be accounted for. The allocation of the group C_2H_6 may be on ethyl and hydrogen or two methyl groups. The investigations of Asahina and co-workers on lichen products show that when substitution by an aliphatic group takes place in a depside ring the substituent always contains an odd number of carbon atoms. Thus the probability is in favour of two methyl groups, rather than one ethyl and one hydrogen. Accordingly we may write the formula tentatively as



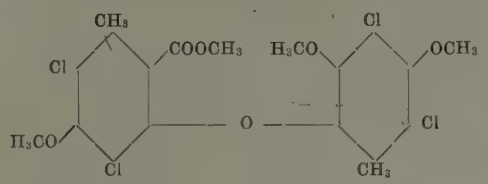
This formula presents the unusual feature for a natural product that every position in each benzene ring is substituted. The most probable allocation of the groups is to regard the compound as produced by the condensation of two molecules of orsellinic acid with subsequent elimination of one carboxyl group and simultaneous chlorination and oxidation.



By analogy with known lichen compounds the more likely position for methylation is the hydroxyl para to the carboxyl group, so that the formula for diploicin would be

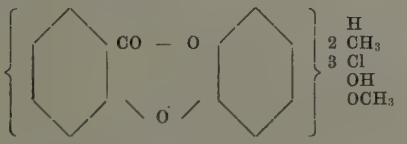


Experiments are in hand on the degradation of diploicin and on the synthesis of the compound



with a view to establishing the above formula.

Regarding the constitution of the trichlor analogue $C_{16}H_{11}O_5Cl_3$ molecular weight determinations in camphor give normal values. Nolan (*loc. cit.*) has shown that depsides of the atranorin type, that is without an oxygen bridge, give values for the molecular weight in camphor half the normal value, and this method has been used by Asahina to distinguish between simple depsides and depsides of the diphenyl oxide type (Ber. **68**, p. 80), consequently this compound would have the structure



The allocation of its three chlorine atoms as between the rings has not been determined.

Experimental.

Extraction of Buellia canescens *with Ether.*

1249 g. of the air-dried lichen was collected in Killiney during the summer of 1934. This was divided into four portions, each placed in a round flask and allowed to stand with 1200–1400 c.c. of ether. The first extract was filtered-off after four days, during which time the contents were kept well agitated, and evaporated to dryness. It gave 29·4 g. of a brownish solid.

The extraction was repeated with the same quantities of ether and the second extract gave 18·1 g. of a somewhat oily solid.

The third extract gave a very oily product weighing 33 g., which did not turn solid on standing in the air.

The fourth extract gave 14·1 g. of a very dark solid which contained only a little oil.

The second extract was treated with 30 c.c. of ether and allowed to stand for three days. The third extract was treated with 45 c.c. of ether and allowed to stand for a similar period. Both products were filtered-off and gave respectively 3·22 g. and 0·47 g. They melted at 195–214° C. and 178° C. respectively. The product from the second extract was amorphous and globular. The third extract residue appeared to be mostly an atranorin-like material. The fourth extract was similarly treated with 15 c.c. of ether, allowed to stand three days, filtered and washed with 5 c.c. ether. 0·49 g. of a residue was obtained.

The first extract and the second extract residue were combined and allowed to stand with 60 c.c. of ether. The whole was then filtered, and the residue washed with 20 c.c. ether. The residue on drying in the air overnight weighed 23 g. It consisted principally of diploicin.

The third extract residue was heated with 5 c.c. of alcohol, in three successive washings, each washing being decanted. The washings were allowed to stand, and the alcohol-insoluble fraction air dried. This weighed 0·32 g., and melted at 209° C.

The fourth extract residue was treated in the same way, and gave 0·3 g. of insoluble material which melted at 207° C.

This treatment with alcohol improved the colour of the products considerably. Their appearance under the microscope, their melting points and general reactions indicated that they were an isomorphous mixture of atranorin and chloratranorin.

Purification of Diploicin fraction.

The 23 g. of the diploicin fraction were boiled under a reflux condenser with 250 c.c. of benzene when practically all the material dissolved. The solution was filtered, and allowed to stand for two days. The material which had crystallised out was filtered-off, washed with benzene, and on drying weighed 14·3 g. This was warmed with 320 c.c. of alcohol under a reflux condenser. The whole was then decanted from the insoluble portion, and the solution allowed to crystallise. The insoluble fraction was found to melt at 225–228° C., and was eventually crystallised from a further amount of alcohol. The crystals deposited from the main solution were filtered-off, washed with alcohol and dried; they melted at 225° C. Both products were combined and weighed 10·5 g.

The product thus obtained was warmed with 320 c.c. of benzene, filtered, and the benzene solution allowed to cool slowly. The coral-like crystals

characteristic of diploicin were deposited, and were filtered-off and washed with a little benzene. On air-drying the product weighed 8·1 g., and melted at 232° C. It was pure diploicin.

The benzene mother-liquors and washings were concentrated down to about 100 c.c. and deposited a white compound having in the main coral-like structure. This was filtered-off, washed with a little benzene, and air-dried; it weighed 0·9 g., and melted at 225–241° C. As the melting range extended beyond the melting point of diploicin a new product appeared to be present. The 0·9 g. was recrystallised from 30 c.c. benzene, and gave 0·4 g. of a product melting at 225–250° C. This in turn was recrystallised from 17 c.c. of alcohol, when 0·14 g. of pure diploicin crystallised out. On evaporating the mother-liquors down to 8 c.c. a product crystallised out which melted at 246–254° C. This product was again crystallised from a small amount of alcohol, and gave about 20 mg. of a product, which on final crystallisation from a small amount of benzene melted at 257° C. (fig. 1).

Analysis.

4·186 mg. gave 7·495 mg. CO_2 and 1·090 mg. H_2O.
5·721 „ „ 6·410 mg. AgCl.
1·23 „ „ 0·760 mg. AgI.
0·309 mg. in 4·020 mg. camphor 8·5° △ Mol. Wt. = 362.
0·205 „ „ 3·380 „ „ 6·5° △ Mol. Wt. = 374.

Found C = 48·83; H = 2·9; Cl = 27·7; OCH_3 = 8·27.

$C_{15}H_8O_4Cl_3(OCH_3)$ requires C = 49·29; H = 2·82; Cl = 27·3; OCH_3 = 7·96.
Mol. Wt. = 389·5.

The product gives no reaction with ferric chloride. It is soluble with difficulty in sulphuric acid, sodium carbonate, and sodium bicarbonate, soluble in 2 % caustic potash, from which it is reprecipitated by addition of acid.

Purification of Atranorin fraction.

The atranorin fractions referred to above as obtained from the ether extract were purified by crystallisation from 40 parts of benzene, and 1·25 g. of product was obtained, which melted at 208–9° C. As the constitution of this product as an isomorphous mixture of atranorin and chloratranorin has been established its examination was not proceeded with.

Extraction of the Lichen with Acetone.

After extraction with ether the lichen was air-dried, and was then extracted three times with acetone. The quantities of acetone used were the same as in the ether extract, but each time the whole was heated on a water-bath under a reflux condenser for two hours. The first extract gave an almost black product,

which contained a considerable amount of oil. The yields from the second and third extracts were very small, and were similar to the first, except that they were not so dark in colour. The extracts were combined, washed with a small amount of ether, and the residue washed further with 5 c.c. alcohol. The product thus obtained was dissolved in 10 c.c. warm alcohol and filtered. A dark oily product separated from the filtrate on cooling. The mother-liquors were decanted from this product, and the residue dissolved in 15 c.c. warm alcohol. On cooling a light brown solid was obtained, which on crystallising from benzene separated in the characteristic form of atranorin, but was darker in colour than the product obtained from the ether extract. The crystals melted at 201° C.

These results confirm the experience detailed in Part I (Nolan, *loc. cit.*) that the acetone extract is a rather unworkable product.

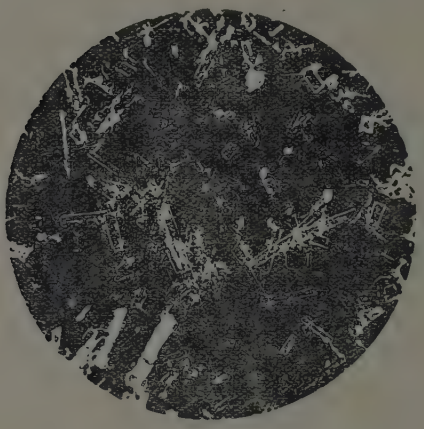


Fig. 1.

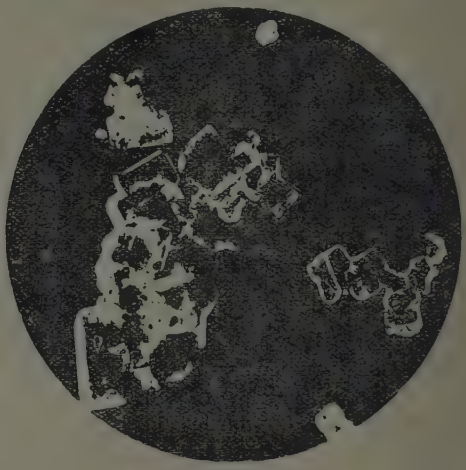


Fig. 2.

Extraction of the Lichen with Alcohol.

The lichen was air-dried to remove acetone, and was then extracted twice with ethyl alcohol on a water-bath. The quantities of alcohol used were the same as in the ether extraction. On concentrating the alcohol extract a hard black cake of material was obtained. This was warmed with 35 c.c. of ethyl alcohol, and filtered from an insoluble residue. An equal volume of acetone was added to the filtrate, and the whole allowed to stand for a few days. Globular aggregates were precipitated, which on crystallising from methyl alcohol gave well-defined crystals of mannitol, melting at 166–167° C. The insoluble residue obtained on treating the original material with ethyl alcohol was heated with methyl alcohol and filtered. The filtrate on standing deposited a small amount of material, which on further crystallisation from methyl alcohol

gave a product crystallising in well-defined rectangular plates (fig. 2) which did not melt below 350° C. This product, notwithstanding its high melting point, leaves no residue on combustion. The amount of material available was insufficient for further investigation. These results confirm those described in Part I (Nolan, *loc. cit.*).

Preparation of Diazo-methane Solution.

4 c.c. of nitroso-methyl-urethane, 80 c.c. dry ether, and 5 c.c. of 25 % methyl alcoholic potash are mixed together in a distilling flask. The temperature at this stage must not rise above ordinary room temperature. The resultant yellow liquid is brought very slowly to 36° C., and maintained at the temperature for 30 minutes, during which period an ethereal solution of diazomethane distils over. The temperature is then raised to 41° C., and after about 20 minutes the distillate comes over colourless, denoting the completion of the reaction. About 40 c.c. of diazomethane solution is obtained.

Preparation of Diploicin Monomethyl Ether.

0·2 g. of diploicin, in 30 c.c. of acetone, was treated with 17 c.c. of diazomethane solution in ether. The whole was allowed to stand for one hour, and the acetone then evaporated-off in the air. The product obtained was crystallised from 4 c.c. of benzene, and a further quantity precipitated by the addition of an equal volume of methyl alcohol to the benzene mother-liquors. 0·15 g. of a product was obtained, which melted at 220° C.

Analysis.

5·107 mg. gave 8·800 mg. CO_2; 1·290 mg. H_2O.
2·909 „ „ 2·880 mg. AgI.
11·596 „ „ 15·010 mg. AgCl.
Found C = 47·0; H = 2·8; Cl = 32·02; OCH_3 = 13·03.
Calculated for $C_{15}H_6O_3Cl_4(OCH_3)_2$—C = 46·57; H = 2·7; Cl = 32·4; OCH_3 = 14·1.

Action of Methyl Alcoholic Potash on Diploicin Monomethyl Ether.

0·05 g. of diploicin monomethyl ether was suspended in a little methyl alcohol, and 0·5 c.c. of 5 % methyl alcoholic potash added. The whole was shaken to complete the reaction. During the shaking the product was not heated beyond 30° C. When clear, the solution was poured into water containing a little hydrochloric acid. An oil was precipitated. The supernatant liquor was decanted, and the product dissolved in hot methyl alcohol. Water was added to the hot solution until turbid. The whole was allowed to cool slowly, and on standing overnight large flat crystals were formed. These were filtered-off, washed with a little aqueous methyl alcohol, and air-dried. 0·04 g. were obtained, m.p. 143° C.

Analysis.

4·682 mg. gave 7·895 mg. CO_2; 1·430 mg. H_2O.
3·549 „ „ 5·325 mg. AgI.
8·510 „ „ 10·355 mg. AgCl.

Found C = 45·98; H = 3·39; Cl = 29·3; OCH_3 = 19·8.
Calculated for $C_{15}H_7O_3Cl_4(OCH_3)_3$—C = 45·95; H = 3·40; Cl = 30·2; OCH_3 = 19·8.

The product is insoluble in sodium carbonate or bicarbonate, but readily soluble in 2 % caustic potash.

Action of Methyl Alcoholic Potash on Diploicin.

0·25 g. of diploicin was dissolved in 50 c.c. methyl alcohol and 5 c.c. of 5 % methyl alcoholic potash added. The whole was heated on a waterbath for 2 minutes to complete the reaction. The product was poured into a solution containing 1 c.c. of hydrochloric acid in 100 c.c. of water. A precipitate was formed immediately. The alcohol evaporated off on standing overnight. The product was then filtered-off and recrystallised from benzene, from which it separated in minute needles. On air-drying 0·2 g. of a product was obtained, which melted at 200° C.

Analysis.

4·866 mg. gave 8·025 mg. CO_2; 1·390 mg. H_2O.
2·187 „ „ 2·085 mg. AgI.
4·450 „ „ 5·430 mg. AgCl.

Found C = 44·98; H = 3·17; Cl = 30·2; OCH_3 = 12·6.
Calculated for $C_{15}H_8O_4Cl_4(OCH_3)_2$—C = 44·74; H = 3·07; Cl = 31·1; OCH_3 = 13·6.

Action of Diazomethane on the Ester from Diploicin.

0·25 g. of the ester (m.p. 200° C.) was suspended in 50 c.c. dry ether, and treated with 10 c.c. of diazomethane solution. On evaporation of the ether a gummy residue was obtained, which, however, went solid on treating with methyl alcohol. It was crystallised from 2 c.c. methyl alcohol, and crystallised in very well-defined needles. On drying in a steam oven the compound reverted to an oil, but regained its crystalline form on further treatment with methyl alcohol. 0·14 g. of a product was obtained, which melted at 97° C., and was insoluble in potash.

Analysis.

4·702 mg. gave 8·215 mg. CO_2; 1·580 mg. H_2O.
3·258 „ „ 6·040 mg. AgI.
9·604 „ „ 11·205 mg. AgCl.

Found C = 47·15; H = 3·69; Cl = 28·86; OCH_3 = 24·46.
Calculated for $C_{15}H_6O_2Cl_4(OCH_3)_4$—C = 47·1; H = 3·72; Cl = 29·3; OCH_3 = 25·6.

Hydrolysis of Diploicin Methyl Ester Dimethyl Ether.

0·1 g. of the product, m.p. 97° C., was heated with 10 c.c. of 15 % methyl alcoholic potash for 1½ to 2 hours under a reflux condenser. The solution was allowed to evaporate in the air, and the residue left standing in a vacuum desiccator overnight. The residue was then dissolved in warm water, filtered, and the free acid precipitated by the addition of dilute hydrochloric acid. It crystallised from ligroin in well-defined stout rectangular prisms. Crystallisation from methyl alcohol was not satisfactory. It melted at 160–161° C., and was readily soluble in sodium carbonate.

Analysis.

11·948 mg. gave 14·445 mg. AgCl.
3·767 „ „ 5·380 mg. AgI.
Found Cl = 29·9; OCH_3 = 18·8.
Calculated for $C_{15}H_7O_3Cl_4(OCH_3)_3$—Cl = 30·2; OCH_3 = 19·8.

No. 37.

THE GLACIATION OF THE BANTRY BAY DISTRICT.

By A. FARRINGTON.

(Plate 8.)

[Read May 26. Published separately August 20, 1936.]

During the glacial period the south-western corner of Ireland came strongly under the influence of the rigorous climate of that epoch. From the extreme west of Co. Kerry to the most easterly part of Co. Cork evidences of the existence of an ice-cap, distinct from the main Irish ice-sheet, are everywhere to be found.

The study of this considerable centre of glaciation, located in that portion of Ireland now especially noted for the mildness of its climate, cannot be without great significance in the discussion of glacial theory in its widest sense. It is greatly to be regretted that so little detailed work has been done in the area.

The present paper is a description of the evidences of the latest glaciation in the neighbourhood of Bantry Bay.

Historical.

The earliest mention of the existence of glaciers in Ireland is that occurring in a paper by Ball (1), in which he mentions the moraines, etc., in some of the valleys in Co. Kerry. Two years later Portlock (2) briefly described boulder-clay and glacial striae at the eastern extremity of Bantry Bay.

The Memoirs of the Geological Survey of Ireland (3) contain descriptions of the drifts of the area. The early period (1861–1864) at which these descriptions were written precludes the possibility of any valuable deductions being drawn; but the descriptions of the deposits, mainly by Jukes, are accurate as far as they go.

Close (4, p. 227) and Carvill-Lewis (5, pp. 84–87) made original observations, but as their surveys covered the greater part of Ireland at a time when access to more remote districts was still difficult, their attention to this area was limited. Wright and Muff (6) recorded many glacial striae, and Charlesworth (7) makes brief mention of the glaciation of the region.

These, with a short note by Reade (8), constitute all the previous literature dealing with the evidences of ice-action in the immediate neighbourhood of Bantry Bay.

The only detailed survey within the sphere of the Kerry and Cork glacial centre is that contained in the special memoir of the Geological Survey of Ireland descriptive of the Killarney and Kenmare district by Wright (9). The Bantry Bay area is immediately S.S.E. of the Kenmare district.

General Topography.

Bantry Bay is one of the great inlets of the sea on the south-west coast of Ireland. Its length is over twenty miles and its width upwards of five. Except where open to the sea, it is completely surrounded by mountainous land. The Bear peninsula separates it from the Kenmare River inlet to the north-west. The backbone of this peninsula is formed by the two continuous mountain ridges of the Slieve Miskish Mountains and the Caha Mountains. The latter range joins without interruption those mountains of western County Cork which lie about the source of the River Lee. In all, for a distance of some 40 miles the summit line never falls below 1,000 feet, except at the narrow gap of Keimaneigh, and only approaches this level at one or two places.

One of the most remarkable features of this upland area is the plateau of the Caha Mountains. Here an expanse of several square miles, studded with small lakes, lies at an elevation of between 1,500 and 1,700 ft. The lakes lie in small rock hollows dammed in some cases by rubbly morainic drift.

The whole of the Bear peninsula was glaciated, with the probable exception of some of the higher summits, e.g., Hungry Hill (2,254 ft.). Drift is rare, only a few accumulations on the southern side being of any importance, but striae may be found everywhere and erratics strew the ground.

South and south-east of Bantry Bay the country is also mountainous. The peninsula that terminates in Sheep's Head is a bold promontory with a spine of rugged hills. But the summits are not high, and wide gaps of inferior elevation give access to country of considerably less relief to the south-east.

The predominant rock is Old Red Sandstone, but at the north-east end of the bay there is an extensive tract of Lower Carboniferous Slate. The same rock fringes the shore of the bay, as it does also at Dunmanus Bay to the south. This latter exposure is united with the wide stretches of Lower Carboniferous Slate which occupy most of south County Cork. The rocks are strongly bedded, and tend to form well-defined ledges. This introduces a difficulty into the study of the glacial phenomena, namely that it is not possible to determine with certainty what are deserted marginal glacial drainage channels of the ice-cap and what are ledges due to the marked bedding. For this reason no glacial drainage channels have been recorded unless they cut deeply *across* the stratification.

General Description of the Glaciation.

The whole area was undoubtedly glaciated from the north-north-west. All along the ridge of the Caha Mountains the glacial striae and rock moulding show this general movement. The series of striae recorded (see Plate 8) leaves

no doubt as to the general direction of the movement, and observations of crag and tail, erratics, roches moutonnées, and drumlins, which will be mentioned later, confirm that the ice came from the north. This is entirely consistent with the observations of Close (4, p. 227), and also with the discovery of Wright (9, p. 56) that the main ice-shed of the Kenmare-Killarney district lay west of Kenmare. Wright shows how the ice in the Kenmare valley pushed north over the flanks of the Reeks to a height of 2,000 feet, while within the Kenmare valley the movement was parallel to the axis of the valley. It is clear that, if there was a centre of dispersal over the Kenmare estuary, the movement at the bottom of the ice would show a strong topographic effect, and would be constrained to move east or west along the bottom of the valley. At the same time, if the ice were thick enough, the upper portions would have a movement to north and south over the bounding ridges. This was doubtless what occurred, and in discussing the details of the survey I shall show examples of such differential movement within the ice mass at different levels under the influence of the surface topography of the land (cf. 10, p. 354).

The ice moved across the Bear peninsula and filled the depression of Bantry Bay. An examination of the directions of striation shows a complex movement within the bay. At the north-eastern end the ice continued its original direction and passed south-east across the bay and out over the hills towards Skibbereen. At the extreme north-east corner, however, the thrust was to east-north-east, and the ice pushed its way up the valleys which drain the south-western slopes of the Shehy Mountains.

Towards the sea the movement was south-west along the lower slopes of the bounding peninsulas, but the bay must have been completely filled, since at the summit of the ridge separating Bantry Bay from Dunmanus Bay striae are found with a south-easterly direction. Of particular interest in this respect are the scratches at Glanlough, and at the gap between Seefin and Caher, where the direction of the striae changes gradually from south-west on the slope facing Bantry Bay to south-east, where the ice passed through the gaps.

The outermost moraines which limit the area of the last glaciation form a fairly continuous series from those in the valleys of the Shehy Mountains to the gravel area near Skibbereen, a distance of about 18 miles. Beyond this latter place the moraine is lost, and the striae indicate that the ice moved off the present shore.

Within this limiting area the general south and south-east movement of the ice is clearly shown by the direction of the striae.

The Drift.

Over much of the district drift is thin or non-existent. This applies particularly to the mountainous parts to the north and north-west. Here large areas are totally devoid of any cover whatsoever, except a very thin soil, which supports a poor vegetation. Frequently considerable stretches of bare rock are exposed. Indeed, even in the more heavily drifted areas to the south-west,

knolls and ridges of naked rock are frequent features. In these bare areas roches moutonnées, striae, and erratics give evidence of glacial action. On the weathered summits of the ridges striae are sometimes difficult to find, as the rock for the most part is a gritty sandstone which weathers rough. At other places slabs many hundred square feet in area are found heavily scored with grooves and scratches up to 10–15 feet in length. There are several examples of this on the plateau of the Caha Mountains. On the less weathered ground surfaces may be seen with the scratches so fresh that the edges of the deep grooves still feel sharp to the touch. A fine example of this is found on the hillside above Kilcrohane by the side of the road as it starts the last long straight up to the pass.

For convenience of description the drift may be divided into 4 different types:

1. Rubbly morainic drift.
2. Boulder-clay spreads.
3. Boulder-clay drumlins.
4. Gravel moraines and outwash.

(1) The rubbly morainic drift is found only locally. The largest accumulations occur near Adrigole, where a valley glacier deposited a fine end and lateral moraine during the later stages of retreat, and at Leitry at the foot of the southern slope of Nowen Hill. Another area of rubbly drift is to be found on the summit of the western end of the Maughnaclea ridge near Lough Nabirree. Pockets and mounds of rubble occur here and there round the margins of the areas covered by the other drifts. These must be ascribed in some cases to late-glacial or early post-glacial weathering, e.g., at the coom of Glanareagh in the Mealagh valley where the rubble overlies a stiff boulder-clay.

This drift consists of large and small boulders, very little rounded, and often quite sharply angular, set in a matrix of finer rock debris and sand. The deposit varies, being sometimes loose and sometimes very firmly set. There is very little clay even in the most compacted parts.

(2) Spreads of boulder-clay occur at the northern end of the bay, the valley of the Barony river being filled with deposits of this type. The valley of the Four Mile Water which flows into the head of Dunmanus Bay appears to contain a similar deposit, but lack of exposures makes a definite statement difficult. A little gravel is to be seen here and there in the valley, but as the present topography is largely due to the dissection of a drift plain this may be explained as redeposited material.

The upper part of the valley of the Mealagh river is in places covered very thickly by boulder-clay in subdued swelling ridges (the seaward end of the valley exhibits marked drumlin topography). No gravel was found in any of the sections seen, and the general form of the ground is that of a boulder-clay terrane.

In this deposit there are many well-rounded and scratched boulders mixed with subangular rubble. The matrix is a very hard sandy clay, particularly

on the northern side of the bay. On the southern side there is less of the subangular material, and the matrix is less sandy. It varies in colour from grey to black. The darkest in colour and most clayey material is found along the southern shore of the bay. This has been derived from the shaly and limy rocks which surround the bay, and is to some extent a confirmation of the direction of the ice-movement.

(3) The drumlins rise in some cases, as near Bantry, from a general boulder clay spread, but often they lie as separate hills or chains of mounds with bare rock exposed on either side. They are "clearly distinguishable from the hills of rock by their smooth regular forms and their green cultivated sides, while the rocky hills are rough, and dark with heather or gorse. The drift hills are round, mostly isolated, mounds of 100 to 150 feet in height, and standing on a base of about half a mile in diameter, with bare rock showing in the low ground between them" (3 (a), p. 45).

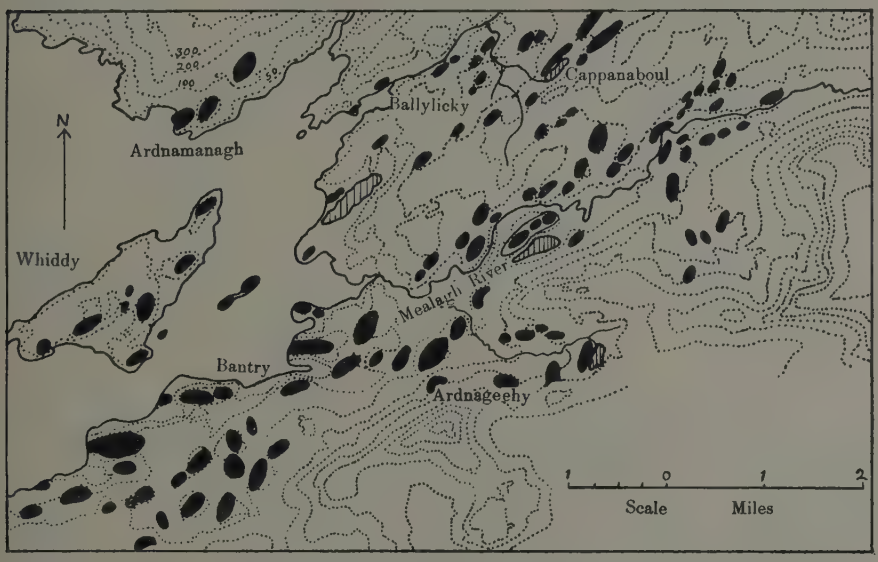


FIG. 1.—Contours at 100 feet interval are shown by dotted lines (the 50-foot contour is also included). Lakes are hatched. Drumlins are shown in full black.

The strike of the rock ridges is in many places parallel to the drumlins, but there is no reason to attribute this to ice action, for the whole grain of the country has this direction. Accordingly, the rock ridges, even when shaped to drumlin form, are not shown (Fig. 1), for it is felt that their direction may not have any real significance for the elucidation of the glaciation. In a few cases the drumlins are undoubtedly formed by the plastering of boulder-clay over the inequalities of a rock knoll; but so far as can be determined many of them are drift all through.

The drumlins are finely-shaped hills, but are not all of typical form, being less elongated than is usual. The high and steep end does not always face the direction from which the ice came (e.g., in the upper Mealagh Valley). The ridges are not symmetrical with regard to the long axis, being often definitely steeper on one side. Examples of these are to be found near Cappanaboul Lake and at Ballylicky. The shape of the former (cf. also Ardnageehy, Fig. 1) might be said to be due to erosion by water impounded between the rocky hillside and the mass of drift, but this explanation cannot be applied to the Ballylicky drumlin, which is isolated, and which has its steep side away from the hill. A further point in connection with the latter shows that the form is not due to recent erosion. The drumlin has been eroded by the sea at the western end, and the exposed cross-section exhibits a zone of weathering in the boulder-clay which maintains the same thickness right across the section.

Many of the mounds are drumlin-shaped only at one end or at one side, and spread out in the opposite direction to a sheet of drift supported upon a rocky platform. Others are of the nature of tails to crags.

It is not easy to say which of the drumlins have rock cores. In some cases, such as those just mentioned, it is certain that the rock forms some sort of a foundation, but in the fine drumlins which have been fully dissected by marine erosion there is no trace of a rock core. At Ballylicky (50 ft.) and Reenrour (about 100 ft.) a great depth of drift is exposed, and yet no rock shows at the base, while at Ardnamanagh (see below) drift to a thickness of 180 ft. is seen to be superimposed on a comparatively level rock surface. This drumlin is much eroded, and from the form of that part which remains it would seem that the section now exposed occurs at about one-third of the length from the original steep end of the drumlin. If there were a rock core it would surely be visible.

The mounds are remarkably uniform in the material which composes them. This is the same stiff grey-black sandy clay of the boulder-clay areas. When unweathered and wet it is plastic and slippery. It weathers to a reddish-brown gritty clay, which is much less slippery than the unweathered material. At first sight this weathered clay might be taken as belonging to a separate formation, as its aspect is so different from that of the unweathered material underlying it, and the line of junction is so sharp. However, the manner in which the junction between the zones corresponds with the curve of the surface of the mounds, and the fact that the constituent pebbles and boulders are exactly the same in both, make it certain that the upper clay is a weathered edition of the lower. The correspondence of pebbles is not apparent without close examination, for the weathering process has removed all the lime, but a careful search will reveal the ghosts of the limestone and cornstone pebbles which are an important constituent of the stony content. The weathering is as deep as 20 feet in places.

The trains of drumlins show a marked tendency to follow the main lines

of the topography; along the Mealagh river the axial direction varies with the curve of the valley.

In the immediate vicinity of Bantry there is some confusion, but to the south-west the drumlins lie along the slopes of the southern shore of the bay with the same general orientation. The majority of the drumlins are shown in Fig. 1, but occasional examples occur along the coast for a distance of seven or eight miles. The orientation of the drumlins agrees with the direction of flow

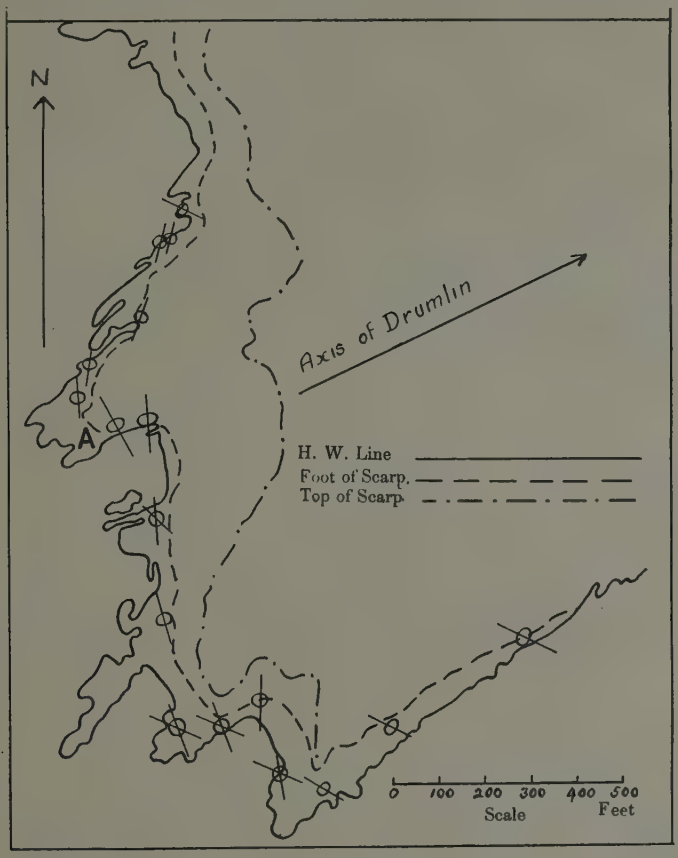


Fig. 2.—Ardnamanagh Point.

of the basal parts of the ice, and the confusion near Bantry and Whiddy occurred where there was most congestion. There was a divide in the basal ice, but the upper parts of the ice must have moved steadily south eastward.

The phenomena connected with the various ice movements, as recorded on the platform exposed at the edge of the boulder-clay of the Ardnamanagh drumlin, are worth recording in detail (Fig. 2). On this platform, as well as

glacial rounding of the rocks, there are two sets of striae. The rounding of the rocks was caused by a powerful ice-movement from the direction of Glengarriff, that is from a little north of west. One set of striae varies 10°–15° east or west of north, and the other is steady at north-west and south-east. The axis of the drumlin itself is E. 30° N.

It is clear that the directions of ice movement represented by the moulding and striation of the rock surface are not directly associated with the direction of movement shown by the shape of the drumlin.

The earliest recorded movement of ice is that from the west-north-west, by which the rocks were strongly moulded. In more than one place, where a rounded hump of rock ends in an easterly-facing crag, the almost vertical face of this crag is striated horizontally or at a low angle. The ice movement recorded by the north-south striae is certainly responsible for the scratching of such faces. An exceptionally good example of this phenomenon is to be seen at (A) on Fig. 2.

The north-west–south-east striae are more difficult to interpret. They are chiefly to be found on the southern side of the head; indeed no other striae are found over a considerable length of exposed rock surface. If they had been made by the rounding ice-movement from the west-north-west one would rather expect them at the western side of the headland. If they had been due to a strong movement from the south-east, then the action of this ice should be apparent on the east-facing crags of the roches moutonnées. They are in the same condition of weathering as the other set of striae, which they cross at the point of the headland. Both sets of striae may be seen disappearing beneath the boulder-clay.

There can be little doubt but that the striae are directly associated with the transport of the drift. It is not likely that 180 ft. of heavily boulder-laden clay could be deposited on an existing striated surface without obliterating the scratches. But the direction of ice-movement, shown by the shape of this particular drumlin, by the general orientation of all the drumlins, and the disposition of the terminal moraines, bisects the angle between the two sets of striae.

It may be suggested that the drift was carried to its present position during an early phase of the glaciation when the basin at the north-eastern end of Bantry Bay was filling up with ice from the north-west. The congestion might cause a movement of local parts of the ice at right angles to the main movement (11, pp. 242–244). There is a suggestion of a further reason for congestion of the ice, other than the topography, in the possibility of a thrust of an ice tongue from the Coomhola valley into the head of the bay. As the bay filled with ice the more normal movement dominated the local variation caused by the topography, and it was this movement that moulded the drift to drumlin form at the maximum or near-maximum of the ice-sheet.

The powerful ice-movement which moulded the rocks must have been earlier than any of these movements, and possibly belongs to a different glaciation.

(4) The gravel moraines, and the chains of mounds and spreads which are found in a belt running north and south from Keimaneigh to Skibbereen are taken as marking the outer edge of the ice at a very important stage. These gravels are typically morainic at the northern end of their range, and lie in roughly crescentic mounds or chains of mounds at the heads of the valleys of the streams flowing south and west from the Shehy Mountains. Jukes (3a, p. 45) commented on this when describing the drift, saying that the accumulations of drift occurred: "sometimes in the bottoms of the valleys, especially near the heads of those valleys on approaching the line of watershed where it crosses a 'pass' or one of the 'lowest connecting gaps' of two neighbouring 'river basins.' "

In most cases glacial drainage gaps lead from the heads of the valleys across the passes; this occurs in every case except one, where the drainage took place across the ridge at the side of the valley.

These gravel mounds could not be formed by glaciers originating in the valleys. There is no sign of coom action at the heads. The gravel itself is clean and well-rounded, and has obviously travelled a considerable distance. In some cases, as in the valley of the Owbeg river, a valley in which the moraine actually lies as a terrace right at the very head, the main deposit is a clean small gravel. Blocks occur in the moraine below the steep slope of Conigar Mountain, but this is to be expected, and many of these are certainly post-glacial. The pebbles found in the gravel are all of sandstone and grit.

Crescentic ridges and ranges of mounds of gravel are found in the valleys of the Owbeg, Owvane, and Owengar rivers. These exhibit the characteristic usual in such moraines, namely that the gravel on the valley bottoms is continued as clay on the higher slopes. In the next valley to the south of the Owengar valley, although well-defined ridges occur, there is no gravel, even the bottom of the valley being occupied by boulder clay.

From Drimoleague southward for a couple of miles runs a continuous train of gravel mounds, best developed just south of Drimoleague, and gradually dying away. For the most part the gravel is fine, with some sand. There are a few coarse beds, but nothing approaching boulder rubble. Gravel benches formed of small pebbles of local rock with some sandy beds occur at Dereeny and Drominidy. About a half a mile away from the latter gravels a remarkable area of rough moraine fringes a hillside, damming up a small lake. Except for the coom moraines of the mountains this is the roughest drift seen, being almost a block moraine with rough boulders of enormous size. Nevertheless this is continued along the valley by a series of gravel mounds which develops, after a small interruption, into a great gravel spread filling the whole of the valley of the Saivenose river. A similar development of gravel is to be found east of Shronecarton along the main road and railway between Bantry and Dunmanway. As both these trains of gravel lead away from moraines in the direction of glacial drainage they may be classed as outwash.

A further area of gravel occupies the valley of the Ilen river just a mile

north of Skibbereen. The gravel is as usual continued out of the valley by spreads of boulder-clay, but the gravel itself, covering an area of about half a mile square, lies right across the valley in flat-topped mounds which rise just to the 50 ft. contour. No morainic drift has been found south of this. These delta-like gravels may indicate the level of a water surface at or near the front of the ice. The position of the gravels suggests that this water may have been the sea.

The great heaps of gravel that lie south of Dromdrasdil do not seem all to belong to the same series, and will be discussed later.

Striae.

The general direction of the striae of this area is north-west and south-east, but there is much variation and some suggestion of a radial movement. For example, near Drimoleague the direction is south-south-east, near Knockaughna south, and near Mizzen Head south-south-west. In several places the direction of striae is found to be at right angles to the normal direction in the immediate neighbourhood. It appears, from an examination of the directions of striae in relation to the contours of the land surface, that the movement of the ice over a wide belt, when unconstrained by the topography, was to the south-east. The striae on the ridge from Hungry Hill to Akinkeen, and those in the open area south-west of Drimoleague, show this. On the other hand, the directions of the striae along the southern shore of Bantry Bay clearly show the effect of the topography. The movement of the ice in the lower parts of this depression was seaward, that is, roughly south-west, but along the top of the ridges the south-easterly movement was still maintained. Evidence of congestion in Bantry Bay is given by the fact that the ice moved up Snave creek in a north-easterly direction and pushed far into the mountains. This was also noted by Close (4, p. 227).

The striae are well preserved all over the area on the north side of the bay, and, at places on the top of the ridge, surfaces are very frequently found where two sets of striae cross one another. It is notoriously difficult to decide which of two sets of crossing striae is the older, and no case was found here for which it would be wise to hazard a determination.

The striae directions which may be associated with the outer moraine that has already been described are dominant in this area, but there are others which do not fit in with that system. A local peculiarity is to be seen in the valley of the Coomhola river. The striae of the Bantry Bay ice-mass diverge about Whiddy Island, and going up Snave creek to the north-east point out the direction of the movement of the ice towards the moraines at the heads of the valleys of the Shehy Mountains. In contrast to this the striae in the Coomhola valley are north and south and north-west and south-east. No north-east striae were seen in this valley.

The Coomhola valley must have been filled with ice from the north before the Bantry Bay ice entered the area. The latter ice was excluded from the

valley, but at its maximum it may even have passed over the valley ice, for the ridge bounding the valley to the south-east was certainly overtopped by the Bantry Bay ice, as is shown by the striae upon it and by the position of the moraines in the upper valley of the Owbeg river.

The ice in the valley probably disappeared before the outlet was free, for there are benches of gravelly drift just north of Coomhola bridge which appear to have been formed in water ponded by the damming of the mouth of the valley.

There are considerable masses of morainic drift a little farther up the valley, and a remarkable accumulation of the rubbly boulder-clay at a comparatively high level on the eastern slope of Cobduff at Kealnine. This may be the remnant of an earlier drift, for it does not seem likely that the ridge north of Cobduff was crossed by the ice-cap under discussion.

Other sets of striae, which may belong to an earlier period, are to be found outside the moraine, and high on the mountains. It is not necessary to discuss those outside the moraine, but those on the mountains within the moraine present a problem. In many cases there can be no doubt that they belong to an earlier period; for example, east and west striae on Nowen Hill just north of Leitry at 1,700 feet cannot be associated with moraines at the level of 700 feet at the foot of the same mountain. Nor can the E. 10° S. striae on Akinkeen at 1,900 feet (S. 30° E., 200 ft. lower down) be associated with the moraines deposited by northward-moving ice at 700–800 ft. in the valley of the Owbeg four miles away to the south. The age of the striae on summits well within the boundary of the moraine, such as at Mt. Gabriel, is very difficult to determine. It is hard to imagine that an ice-sheet which had its margin at Skibbereen should have overtopped Mt. Gabriel, yet the striae on that hill at 1,200 feet are well preserved (4, p. 227). It is because of this doubt that I have only considered the striae in low-lying areas when discussing the direction of movement of the ice. The full interpretation of the glacial history even of the area inside the last moraine must await the working out of the glaciation of the outlying districts.

Erratics.

It has been mentioned that the area has been liberally strewn with erratics. This is particularly noticeable on the north side of the bay along the road running from Glengarriff to Adrigole. Here large ice-borne blocks lie everywhere on the bare rock surfaces. These are all derived from the grits, coarse sandstones, and sandy shales, which form the ridge of the Caha Mountains. All the erratics on the north side of the bay are of these local rocks. In the drumlin area to the south-east the erratics in the drift are the same, with the addition of boulders of the "cornstones" and the rocks of the Lower Carboniferous Slate which fringe the bay. Jukes (3a, p. 45) comments on the fact that in this drift there are few boulders of the purple grits of which the surrounding hills are formed, and, as the carriage of erratics had been chiefly

from the Caha Mountains where the grey grits predominate, this point is an additional indication of the direction of movement of the ice.

By far the most interesting erratics are the large blocks of crystalline limestone which occur on the south shore of the bay. These are typical crinoidal limestones of lower Carboniferous type. Their distribution is marked on the map (Plate 8). They cannot have come from outside the valley, as it is inconceivable that they could have been carried from the limestone exposures at Kenmare without leaving a single example on the ranges to the north of the bay. They can only have been derived from an exposure of Carboniferous Limestone now covered by the waters of Bantry Bay. The largest of these boulders, a rectangular block measuring 4′ 6″ × 3′ × 3′, lies on the shore near Relane Point. The distribution of the boulders considered in relation to the direction of movement of the ice, gives some idea of the position of the limestone.

Dry Gaps.

All the glacial drainage channels to be described cut across ridges of rock out of valleys in which water had been ponded by the ice advancing from the lowland surrounding the bay towards the higher land on the south and east. Owing to the rock structure which forms series of well-defined ledges along the sides of the valleys it has not been possible to determine with certainty any of the channels at the side of the ice tongues, though such undoubtedly must occur.

There are eight of these "terminal" drainage channels—i.e., those which lead directly away from the ice-invaded area to new catchments—and half a dozen others, which either connect two ice-invaded valleys or are continuations of the drainage of channels of the first type. Of the former undoubtedly the finest is the pass of Keimaneigh, which leads from the Owvane valley to the upper valley of the Lee. The intake of this channel is at 650 feet at the head of the Owvane valley, just beyond a small moraine which marked the extreme limit of the intruding glacier. The road which passes through the gap enters abruptly into a gorge, the sides of which almost immediately rise to 150–200 feet, and runs thence for a mile and a half, with a total fall of about 250 feet, through a deep valley with high rock walls to the wide valley of the Lee. There is no accumulation of gravel at the outfall.

The drainage through this must have been considerable, for it carried the melt waters not only of its own valley but also that of the Owbeg, which entered the Owvane valley by the Cappaboy gap, and also that of the Gortloughra valley, the only other outlet of which, a small one, occurs just below 900 feet.

The Cappaboy gap cuts across the ridge dividing the Owbeg from the Owvane valley. The intake is the western side of the ridge at between 750 and 800 feet. The floor of the channel is very rough, being much encumbered with material fallen in quantities from the sides. It is in all about half a mile long, and dies out near Cappaboymore at below 700 feet. At the outfall there are

flat benches of rough drift, which probably represent the detritus carried through the channel.

Only a very small channel records the existence of the drainage through Cousane gap at the head of the Owengar valley, but a fine one occurs at the head of the Mealagh valley. This, the Barrboy gap, is the highest in the district, the level of the floor being just at 1,100 O.D. It has a maximum depth of 50 feet, and is about a quarter of a mile long. Its outfall is down a very steep slope to the upper waters of the Bandon river which flows in a wide flat at between 400 and 500 O.D. There is no gravel associated with the outflow, but the valley of the Bandon river towards Keenrath and Togher is filled with a gravel spread. Cousane gap and the gaps to the south near Coolkelure might also have contributed to this.

The Barrboy gap seems certain evidence of water ponded in the Mealagh valley, but, if so, it is remarkable that there are no gravel moraines in this valley. I can offer no explanation of this. The drift in the lower part of the valley is thick. Sections of 20 or 30 feet and in one case 60 feet are to be seen. The striae show clearly that the ice came up the valley, and, therefore, must inevitably have ponded water at different stages, but not one heap of gravel is to be found.

The drainage of the Clodagh valley, dammed up by the Leitry moraines, flowed out north past Cullenagh, ultimately entering the valley of the Bandon river. The channel although not large is very well marked, and is of importance, as it cuts across an area of older moraine associated with striae with direction quite at variance with those we have been discussing. This is the only place where the marginal phenomena of the later phase come clearly into contact with the earlier drifts.

The main road and the railway from Bantry to Dunmanway pass through an overflow channel about four miles west of the latter town. The great chain of gravel mounds at the southern end of the Leitry-Clodagh moraines lies at the head of this channel, and the valley of the Brewery river, at its outfall, is filled with gravelly drift, as is the valley of the Dirty river to the north. Tributary channels are seen on the slope of the hill to the north.

A great mass of gravel occupies the upper part of the Saivenose river valley, and spreads over the watershed into that of Curraghalicky lake. This lake drains away to the Bandon river through an old glacial drainage channel. A small gap at over 1,100 feet crosses the ridge south-west of Coomanore lake. From its position and that of the drift at Coomanore it may be inferred that the upper limit of the ice in this locality was at this level. The ridge above is much shattered and weathered.

The new subsidiary channels that occur require no explanation; their relations to the main lines of drainage are quite clear. There is, however, one terminal channel at Foherlagh the relations of which are difficult to establish, since there exists no morainic accumulation which might give a clue to the disposition of the ice front, and without a great distortion of the phenomena already described it is difficult to suggest anything except some local peculiarity.

One further matter should be mentioned in this relation. Many of the streams now enter the sea in gorges or over waterfalls. It might be suggested that some at least of these were due to glacial diversion of drainage; but this is hardly likely, since the delta-like moraine at Skibbereen seems to indicate a submergence in late glacial times of about 50 ft., which would sink all these gorges below sea level.

In certain cases, e.g., the mouths of the Owvane and the Mealagh rivers, the fall might be due to the choking of the old bed by drift, but in the case of the Coomhola river close by there can be no such suggestion, as there is a continuous rock ridge for miles on either side of the gorge. The river here leaps into the sea in the middle of a potholed gorge. Many more of these gorge-like river mouths may be found round the coast; a few are mentioned—Leap, Castlehaven, Roaring Water river, Skull river, Ahakista river, Friendly Cove. The peculiarity of the Lough Ine inlet would require a separate treatment. The phenomenon is common all around the coast, and seems to be due to a slight uplift in comparatively recent times. This is a point of great interest, for round the rest of the coast of Ireland we have to deal with submerged rather than uplifted river valleys. The south-west corner appears to be in a different topographic province from most of the rest of the island.

Coolkellure–Cullenagh Drifts.

Near Coolkellure House and the hamlet of Cullenagh enormous heaps of gravel drift form conspicuous features. The gravels are very similar to those occurring in the moraines already described in this paper, but they are considered to be the deposits of an earlier glacial phase for the following reasons. They lie outside the ridge of mountains which in all other cases contain the moraines. Although prominent they are not sharp-featured, except where eroded. At Cullenagh a glacial drainage channel from the front of the Leitry morainic series cuts across one of the areas of gravel. In a section on the hillside opposite Cullenagh laminated clay is seen in association with these drifts. While the extent of this lake deposit is not known, and admittedly it may have been deposited in a comparatively small pocket, only ice at the northern end of the valley could pond water therein. The striae crossing the ridge of Dromdrasdil run east-south-east, and the rounding of the rocks shows that the ice came from the west-north-west. Lastly, the drainage through a channel leading away from the deposit at Derryduff flows south.

It does not seem possible to fit all these circumstances in with the ice which deposited the series of moraines extending from Skibbereen to Keimaneigh, so that one is forced to consider the Coolkellure–Cullenagh drifts as belonging to a different glacial phase from those dealt with in detail in the present communication. From their position and relation to the glacial drainage they must belong to an earlier glaciation.

Retreat.

Except in the early stages there are not any signs of the retreat of this ice-sheet.

In the valleys of the Shehy Mountains successive moraines covering a space of two or three miles form concentric series convex up the valley. On the scale of the accompanying map (Plate 8) it is possible to show only the larger of these. The successive ridges crossing the valley of the Owengar are particularly striking. Three fine arcs of gravel mounds cross the valley, as shown in the map, but at the head of the valley twelve moraines are found within the first half-mile west of Cousane Gap.

South of Drimoleague the gravel ledges east of the railway, and the moraine at Skeagh, may represent a stand of the glacier, but it is not certain. The most that can be stated is that there is a morainic belt three or four miles wide around the glaciated area, and that no moraines are found within this belt, with the exception of a few corrie moraines in the mountains. There are no traces of a retreat by stages.

It should be noted that, as this sheet was fed entirely or nearly so—there may have been some precipitation on the high parts at the maximum—from an accumulation area at the other side of a high ridge, its supply would have been cut off abruptly. The retreat from the highest to the lowest moraines in the Shehy valleys represents a fall in the level of the ice front of about 250–300 feet, and may have been the effect of a steady diminution in supply due to climatic causes; the ice-sheet still remaining alive by reason of its connection across the Caha ridge with the main accumulation area in the Kenmare valley. Once the connection was severed the ice in Bantry Bay was dead, and melted *in situ* without any forward movement to form moraines.

Some General Considerations.

Since there is little drift outside this moraine, and since the surface, particularly to the south-east, is weathered and shattered wherever rock is exposed, it may be assumed that the broken line of the moraine from Keimaneigh to Skibbereen was formed at the extreme edge of the ice-sheet. The only drift of any thickness is the gravel lying in the valleys which were directly connected with the drainage from the ice front. This statement is necessarily tentative until much more of the ground to the east has been surveyed, but it is supported by a brief notice by Jukes on the scarceness of the drift in the area east of that just described (3d, p. 27). Within this belt of moraine no other terminal accumulations are formed except near Adrigole and in the corries. The latter are very unimportant in this area, and the Adrigole moraine lies at the mouth of a valley which has its head at Ballaghascart, the lowest pass in the Caha ridge, where a later connection with the Kenmare ice than in other parts of the area was possible. It is probable, therefore, that the glaciation described was the last in the area.

Summary.

The area around Bantry Bay was invaded by an ice-sheet coming from the north-north-west over the ridge formed by the Caha and Slievemiskish Mountains, which were overwhelmed to a height of about 2,000 feet. The bay was filled with ice, which escaped south-westward along the bay; north-eastward up into the mountain valleys, where fine terminal moraines are found; south-eastward as far as Skibbereen. The terminal moraine of this sheet may be traced for about twenty miles from the pass of Keimaneigh to Skibbereen.

The press of ice coming down the Glengarriff valley was congested at the head of the bay, and there was much differential movement within the ice-mass.

Drumlin trains follow the north-eastward and south-westward ice movements, but only to a small extent that which took a south-eastward direction.

The occurrence of erratics of Carboniferous limestone points to an outlier of this rock beneath the waters of the bay.

The ice-sheet described is considered to have been the last in the district.

The author is indebted to the Royal Dublin Society for a grant in aid of the expenses of this survey.

EXPLANATION OF PLATE 8.

Contours, every 500 feet, are shown by dashed lines.

Lakes are shown in full black.

Morainic areas are stippled, and spreads of boulder clay are shown by stippling, with triangles.

The letter L is used to indicate the distribution of limestone boulders.

Glacial striae are shown by circles with straight lines through them.

Glacial drainage channels are shown by arrows.

Drumlins are not included in this map.

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No. 38.

THE STANDARDISATION OF PHOTO-ELECTRIC CELLS FOR THE MEASUREMENT OF ENERGY.

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Introduction.

It is desirable, when measuring radiation, to be able to do so in a number of different regions of the spectrum, since this gives information as to the energy available for special biological processes which are brought about by selective absorption of different wave-lengths. For example, the sensitivity of the human eye has a well-defined maximum for moderate illuminations about 555 $m\mu$, the photo-synthetic sensitivity of chlorophyll is low in the green, and the production of erythema in the skin is limited to wave-lengths below 315 $m\mu$.

The use of thermopiles with selective filters, though an obvious method, presents certain difficulties, which will be discussed later. On the other hand, photo-electric cells, having unequal sensitivities for different wave-lengths, are only suitable if a careful study is made of their properties. Their high sensitivity, instantaneous response, and also their insensitivity to long-wave radiation, are, however, such important advantages that we have attempted to effect their standardisation with the help of filters, so as to measure the radiant power or energy per second in definite spectral regions in microwatts per square centimetre per microampere of the photo-electric current.

This method of presenting results is also free from the objection urged against the use of visual photometric units for the visible spectrum, namely, that the measurements are made on some photo-electric scale which is not that of the eye.

Standardisation in absolute energy units, while simple in theory, presents some difficulties in practice. It has been adopted by Clarke (3) for his measurements of the penetration of daylight into oceanic waters. A lamp at a colour temperature of 2835° K was used as a source, but he only gives a brief description of the standardisation, which was carried out with the aid of radiation data supplied by the General Electric Co., U.S.A.

Choice of Method.

There is little use in stating that a reading of a cell sensitive in a varying degree to a large part of the spectrum corresponds to a certain number of

milliwatts per square centimetre in that range unless we are certain that the energy distribution of the radiation which we are measuring resembles that of our standard source over the range. This condition is not satisfied if such a cell is standardised by artificial light and used to measure daylight, so we must divide our spectrum up into blocks by the use of colour filters (or cells of short ranges of sensitivity), each block covering a range of wave-lengths short enough for the variation of energy distribution within it to be neglected, or approximately allowed for. We can thus, by summing the energies in the various blocks, find the energy in the complete range of daylight covered by the cell without filter, and use the constant so found to obtain from a single reading without filter an approximate value of the energy in the same range on some other occasion. The accuracy of the result will depend on the similarity of the spectral distributions on the two occasions. For greater accuracy each measurement should consist of a set of readings with different filters.

If a suitable set of filters were available, each transmitting highly inside a limited range of wave-lengths and not at all outside it, we could calibrate our filter—cell combinations by measuring with a thermopile the energy from any constant source transmitted by the filter, and observing the corresponding reading of the cell under this filter. We could obtain the incident energy within the given range by multiplying the energy recorded by the thermopile by a factor to correct for the absorption of the filter within its range of transmission, and thus obtain the energy constant of the filter—cell combination for that range. This method appears to have been used by others, but unfortunately various practical difficulties arise.

(*a*) Most filters which only transmit in a narrow band of the spectrum show heavy absorption within that region, and often have other transmission bands. Thus, the Corning Sextant Green filter, glass 401, which we have used much, has a maximum transmission of only some 14 per cent. in the green, and transmits some of the far infra-red which would affect the thermopile. This means that we must have a very accurate knowledge of its transmission curve, and must cut out the infra-red by means of an additional filter, whose transmission curve must also be known. Many other blue and green filters may transmit infra-red of wave-length short enough to affect the photo-electric cell.

(*b*) Even if an infra-red screen is permanently in position the warming of the filter by the radiation absorbed causes a rapid drift of the thermopile zero, which reduces the reliability of the measurements.

(*c*) If, as is probable, the transmission range of the filter lies in a region where the sensitivity of the cell is changing rapidly with wave-length the readings of cell and thermopile are not comparable. Thus, as an extreme case, the transmission band of the filter may extend beyond the range of sensitivity of the cell. The filter—cell combination will then measure a shorter band than the filter—thermopile. This effect will occur with many of the filters mentioned below, whose transmission bands extend far beyond the red limit of the selenium rectifier cell.

An alternative method is possible if a source of known spectral energy distribution is available. By inspection of the curve obtained by multiplying the transmission of the filter for diffuse light by the sensitivity of the cell for the given wave-length we can, if the "cut-off" of the filter is reasonably sharp, choose a block of the spectrum, bounded by definite limits, to the energy in which the reading may fairly be ascribed. This energy, for the standardising source, can be found from the known spectral distribution and the total energy per sq. cm. at the given distance. If the spectral block is not too extensive the error due to the difference of energy distribution within it between the standard and the source to be measured will not be unduly large. We must, of course, ensure that any transmission bands that may occur outside the given block lie outside the range of effective sensitivity of the cell. Thus certain blue filters could not be used with Bolton King's X type cells owing to their transmission of infra-red, to which, up to 1100 $m\mu$, this cell is very sensitive.

We shall deal in the first place with the use of this method for the standardisation of the Weston selenium rectifier cell No. 21104/2, of which we have made much use.

Colour Filters.

It is difficult to obtain a set of filters giving the required spectral regions and possessing the requisite stability, and we have found it necessary to use a differential method for certain ranges towards the red end of the spectrum. Figure 1 shows the spectral transmissions of the glass filters which we have used for this standardisation. The curves for the Jena filters, BG 12, GG 11, RG 1, RG 8, and RG 7, are plotted from the curves and measurements supplied by the makers, Messrs. Schott and Gen, allowance being made for the reflection losses of the surfaces in the diffuse light below the opal-flashed glass, and for the increased effective thickness of the filter due to the average obliquity of this light. The latter allowance is hard to make with accuracy, but the mean of a number of tests with approximately non-selective filters under and over an opal glass showed that the effective thickness of the filter was about 1·15 times as great for diffuse as for perpendicular light. Thus, the Jena filters, whose thicknesses were all close to 2·0 mm., were taken as having effective thicknesses 2·3 mm.

The figure also shows the curve for the Corning Sextant Green filter, whose use in an alternative system of spectral division we consider later. This curve is taken from our own measurements, allowance being made for the effect of obliquity in increasing the effective thickness from 4·0 (the actual value of the thickness) to 4·6.

Considering first the sole use of the Jena filters, we see that, with the exception of BG 12 and RG 7, their transmissions are over 90 per cent. from far in the infra-red to a fairly sharp cut-off in the visible spectrum; thus, the difference in the readings with two such filters may be taken as a measure of the energy in the region between their lower limits of transmission. This

differential method of working has, however, serious objections, especially for the measurement of a variable source, such as daylight. It becomes quite useless in the blue end of the spectrum, as this is so weak in the radiation from the standardising source that the differences between the readings with successive filters are altogether too small to be used with any confidence. Fortunately, in this region the filter BG 12 is available, giving with the Weston cell a fair measure of the block 360 $m\mu$ to 500 $m\mu$. The blocks covering the remainder of the spectrum have also been made somewhat wide, thus ensuring large differences between the readings, and reducing the number required. The width of a block, however, may cause an appreciable error in estimating the energy in it for radiation differing greatly in distribution from the standard source. This point is discussed later. The filter RG 7 is useful for the region just beyond the end of the visible spectrum. It transmits scarcely any visible light, the sun's disc being only faintly visible through it. This filter could be used with advantage with King's X 16 cell to measure infra-red radiation of wave-length up to about 1100 $m\mu$.

In fixing the arbitrary limits for the various blocks, as given in Table 1, we must be guided chiefly by the sensitivity curves for the cell with the various filters in position, as shown in the upper part of Fig. 2.

Source of Radiation.

The provision of a source suitable for standardisation, especially towards the violet end of the spectrum, is likely to be difficult in most laboratories. The carbon arc may be ruled out, though its high colour temperature is tempting. Unfortunately, although, as we have previously shown (8), it appears to be a reasonably constant and reproducible source when used under proper conditions, it suffers from two grave defects when it is desired to estimate the energy in its spectrum, assuming its colour temperature to be known. Firstly, there is much long-wave radiation from the cooler parts of the carbons, so that the colour temperature of the crater is no measure of the proportion of the total energy that lies in any particular range of wave-lengths; and, secondly, the arc itself radiates a large and unknown amount of deep violet and ultra-violet.

We have used a sub-standard vacuum tungsten lamp, whose filament is wound vertically, so as to occupy a plane rectangle about 6·5 cm. × 3·3 cm. This is certified by the National Physical Laboratory as having a colour temperature of 2360° K when taking a current of 0·7300 ampere, the voltage across the terminals being 96·20 and the horizontal candle-power 51·0. The temperature is considered to be correct to within 10°, and is on the new scale adopted in 1932, following the latest determination of the melting point of platinum. The corresponding temperature on the old scale, for which the energy distributions in the International Critical Tables are presumably calculated, is 2320° K, and this figure has been used in finding the energy in the various spectral blocks.

A source at a higher temperature, as used by Clarke, would have the advantage of greater richness in the blue and violet. It would, however, entail the use of a gas-filled lamp, whose constancy would almost certainly be inferior. Moreover, loss of heat by convection would prevent any satisfactory attempt to deduce the total radiated energy from the power input.

In carrying out our standardisations the lamp and the cell with filter and diffusing glass were set up on a photometer bench, the usual precautions being taken to prevent appreciable errors from being caused by reflected, scattered, or extraneous light. It is necessary for the filter to be placed between the cell and the diffusing opal, and in use in the open air the filter is laid on the horizontal rim of the cell and the opal on the filter. Accordingly the same relative positions must be maintained when the combination is standardised in a vertical position. This was done with the aid of a little plasticine at the edges holding the surfaces in contact, as when used horizontally. It is also desirable that the front surface of the opal should always be at the same distance from the lamp, whether a filter is present or not. This is most easily effected by means of a distance piece. The distance from the filament plane to the diffusing surface was exactly 40 cm. At this distance the correction for the sizes of the source and photometer window only amounts to about 0·75 per cent. Allowance has been made for this in finding the values for the energy given in Table 1.

The current through the lamp was supplied by a D.C. dynamo, driven at very nearly constant speed by an A.C. motor, and was adjusted accurately by means of one coarse and two fine rheostats. It was measured by means of a standard 4-terminal ohm and a potentiometer, and maintained by hand regulation at the prescribed value. It was not convenient to measure the voltage also during a standardisation, but a preliminary test showed that for the standard current through the lamp the voltage at the lamp terminals, as measured with potentiometer and volt-box, was sufficiently close to the N.P.L. figure to justify the assumption that no appreciable change had occurred in the lamp due to evaporation of the filament in the course of the few hours during which it had been in use since standardisation.

The current supplied by the cell was measured by the modification of Campbell and Freeth's method which we have already described (7).

Calculation of Energy.

To find the radiant power, or energy per second, per sq. cm. in each spectral block falling on the diffusing surface let us commence by assuming that the radiation from the filament is similar to that of a black body at 2320° K (old scale), not only in the visible spectrum but throughout its entire range. We can then calculate the proportion of the total energy that lies in any spectral block from the table given on pp. 239 *et seq.*, vol. 5, of the International Critical Tables. This can be done most simply by using the figures for 2400° as a basis, and multiplying the chosen wave-length limits of the

various blocks by 2320/2400 to correct for the difference between the actual colour temperature and the table temperature. We can make further use of Wien's displacement law to obtain extra figures at either end of the table, but in this case a reduction factor must also be applied to the table entry. Thus, 300 $m\mu$ at 2400°, for which the entry is $3{\cdot}46 \times 10^9$, corresponds to 600 $m\mu$ at 1200°, for which the entry is $1{\cdot}08 \times 10^8$. We can thus obtain the appropriate entries for 310 $m\mu$, 320 $m\mu$, etc., at 2400° by multiplying those for 620 $m\mu$, 640 $m\mu$, etc., at 1200° by 34·6/1·08, i.e., by 32·0. We can similarly extend the table at the other end by converting the figures for some high temperature. Those for 6000° are convenient, and enable us to extend our 2400° entries up to 25,000 $m\mu$, above which the radiation is negligible. It is easy from the table thus extended to find the energy integrals in table units (*a*) for the complete spectrum, and (*b*) for the portion lying between any desired limits, and so to find the proportion of the total energy that lies in any desired block. In the long-wave region, where the entries are rather sparse, we may use Simpson's rule. In the visible spectrum simple addition of the ordinates is probably sufficiently accurate, but, as the reduced wave-length limits will not generally coincide with any table entries, we must make suitable allowances and interpolations at the ends of each block.

TABLE 1.

Calculation of energy in various blocks of the spectrum of the standard lamp, colour temperature 2360° K (2320° K old scale), from figures given in the International Critical Tables for a temperature of 2400° K. The lower part of the table shows an alternative method of sub-division for wave-lengths above 500 $m\mu$.

Filter or F. Diff.	Assumed Range for 2320° K, $m\mu$.	Corr. Range for 2400° K, $m\mu$.	Energy Integral in Table Units.	Percentage of total, p.	1·324 p.	Energy at 40 cm. dist. μw per sq. cm.
BG 12	360–500	348–483	$2{\cdot}97 \times 10^{12}$	0·1575	0·208	9·04
GG 11-RG 1	500–600	483–580	11·52 ,,	0·612	0·810	35·2
RG 1-RG 8	600–700	580–677	27·62 ,,	1·467	1·94	84·4
RG 8	700–820	677–793	58·68 ,,	3·115	4·12	178·6
No Filter	360–820	348–793	100·79 ,,	5·352	7·08	307·2
Beyond range of cell	820–25,900	793–25,000	1784 ,,	94·65	—	4033
			1885 ,,	100·0	—	4340
Corn. Green	500–600	483–580	11·52 ,,	0·612	0·810	35·2
RG 1	600–760	580–735	53·64 ,,	2·85	3·77	163·5
RG 7	760–860	735–831	58·90 ,,	3·125	4·14	179·5
No Filter	400–760	387–735	67·93 ,,	3·60	4·765	206·8

Table 1 summarises the results obtained in this way, the second column showing the wave-length limits assigned to the energy measured by readings, or reading-differences corresponding to the filters given in the first. The third column shows the corresponding wave-length limits reduced from 2360° (new scale) to 2400° (old scale). The fifth column shows the percentage of the total energy lying in the given block, as found from the energy integrals given in the fourth, while the sixth gives this percentage multiplied by 1·324.

This factor, which is required in order to correct for the fact that tungsten radiates relatively less in the infra-red than a black body at the same colour temperature, is derived as follows. We find on pp. 245 and 246, vol. 5, of the International Critical Tables that for a True Temperature 2300° K the Colour Temperature of tungsten is 2347°, the Brightness Temperature ($\lambda = 665\,m\mu$) is 2109°, and the Radiation Temperature is 1688° (by interpolation). This means that we may regard a filament at 2300° true as equivalent in relative distribution within the visible spectrum to a black body at 2347°, although the energy radiated by each square centimetre is less, since the radiation between $664{\cdot}5\,m\mu$ and $665{\cdot}5\,m\mu$ is only equal to that of a black body at 2109°. We find from the radiation formula that a black body at 2109° radiates 0·3545 of the energy proper to 2347° for the wave-length $665\,m\mu$. Thus the filament only emits 0·3545 times as much energy of wave-length $665\,m\mu$ as a black body at the appropriate colour temperature. Since the distributions within the visible spectrum are similar, the same ratio is approximately correct throughout that region.

On the other hand, the relative deficiency in the total energy emitted by the filament is even larger. As the radiation temperature is only 1688° the total energy is only $(1688/2347)^4$, i.e., 0·2677 of that emitted by the black body at 2347°. Thus a tungsten filament at a colour temperature 2347° (i.e., a true temperature 2300°) emits a greater proportion of its energy in the visible spectrum than a black body at the same colour temperature, the ratio being 0·3545/0·2677, i.e., 1·324. The factor for the actual colour temperature, 2320° on the old scale, must be very close to this.

We can find the total energy radiated by the filament in the given direction either from a knowledge of the power input or by direct measurement with a thermopile. The first method is much the simplest experimentally, but involves a small error due to loss of heat by conduction at the filament supports, and possibly some appreciable transference of heat through the trace of residual gas in the exhausted bulb. The second method, though theoretically preferable, involves the accurate standardisation of the thermopile, and its use under conditions similar to those used in standardising. Thus, the reading of the large surface Moll thermopile, which we have used, continues to rise for a considerable time when exposed to radiation, as the metal rim in front of the sensitive surface gets warmer, so introducing some uncertainty into the readings. Moreover, if a shutter is used to cut off the radiation, care must be taken that radiation from this shutter does not raise the zero, and so reduce the reading.

This method also necessitates a correction for the long-wave radiation stopped by the lamp bulb, since we require to know the total radiation emitted by the filament in order to calculate the energy in the various blocks of the visible spectrum.

Fortunately, the two methods agree tolerably well. Thus, the standard lamp during test took 0·7306 amp. at 96·3 volts, or 70·4 watts. It is evident, in view of the length of the filament loops and the absence of noticeable dimming of the filament at the ends, that the conduction of heat is small. The heat transference through the residual gas is probably also small. Neglecting these losses, it is evident from a simple integration that the radiation per unit solid angle in a direction normal to the filament at a distance large compared with the dimensions of the lamp would be $70{\cdot}4/\pi^2$, i.e., 7·13 watts per square radian if no long-wave radiation were stopped by the glass.

Measurements made with the Moll large surface thermopile at a distance of 40 cm., using the constant determined by the makers, gave a value corresponding to 6·33 watts per sq. radian, a small correction (about 0·6 per cent.) having been introduced for the size of the lamp. The zero was found by switching off the lamp, and sufficient time was allowed for the deflection to become constant before each reading. From inspection of the curves for crown glass, given on p. 271 of the International Critical Tables, vol. **5**, it would seem that the thin glass of the bulb should cut off fairly sharply about $4{\cdot}5\mu$, and from the table on p. 240 (*ibid.*), we estimate that about 7 per cent. of the radiation of a black body at 2400° K is above that wave-length. For tungsten at a colour temperature 2320°K (old scale) the value would probably not be very different, the lower temperature tending to compensate for the relative weakness of tungsten radiation in the infra-red. Thus, an external radiation of 6·33 watts would correspond to a total radiation 6·82, as compared with the input value, 7·13 watts per sq. radian.

We have adopted the mean figure 7·0 watts per sq. radian for the total radiation. This corresponds to 4·34 milliwatts per sq. cm. at 40 cm., when allowance is made for the sizes of the lamp and thermopile. This value is used in Table **1**.

Correction for Differences in Energy Distribution.

The spectral distribution of energy for a source at 2320° K (old scale) is plotted on a convenient scale in Fig. 1. The upper part of Fig. 2 shows the sensitivity curves of the cell under opal glass, and with various filters placed below the opal, for an equal-energy spectrum, and the lower part shows the corresponding response curves for the 2320° radiation. The sensitivity values for the cell were obtained from our own measurements in the visible spectrum and by estimation from a curve for a similar cell, as found by the makers for the regions on either side of the visible. Allowance has been made for the effect of the opal-flashed glass used. This has a slightly greenish tinge when viewed on edge, and a test with our monochromator showed that its transmission

varied continuously throughout the visible spectrum, its value at 400 being only about 60 per cent. of that for 700 $m\mu$.

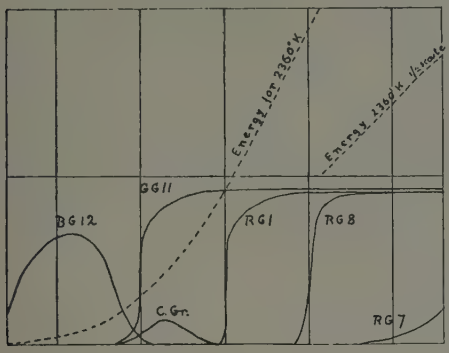

FIG. 1.

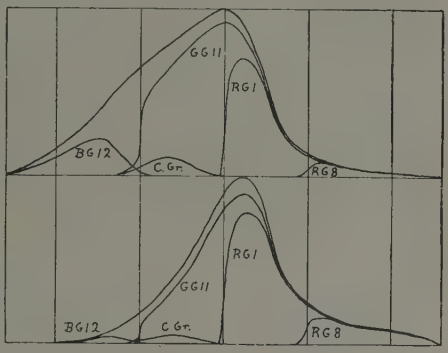

FIG. 2.

The curves for RG 7 have been omitted from Fig. 2, as the low transmission of the filter, combined with the low sensitivity of the cell, renders the product too small for plotting on the same scale as the other filters, and it is hardly worth while to plot on a larger scale without more accurate knowledge than we possess of the sensitivity of our cell in the near infra-red.

We use the curves plotted in Fig. 2 to fix the limits to be assigned to each spectral block, and also to estimate the error that will arise with varying spectral distributions owing to the finite width of the blocks. It is evident that the centre of gravity of the response curve for the lamp is, in every case, shifted towards the red, as compared with that for the corresponding equal-energy sensitivity curve. We may adopt the latter as a standard for the measurement of daylight, since over a considerable part of the visible spectrum the equal-energy distribution is intermediate between those of sunlight and blue sky light. This variation between the equal-energy and 2320° curves will have the greatest effect on the relative areas, and hence on the relative energy constants in cases where the curves are very unsymmetrical, or where, for motives of convenience, limits have been assigned to the blocks differing appreciably from the best possible choice for the given filters.

Table 2 shows the estimation of the approximate corrections needed to obtain the energy constants for an equal-energy spectrum from those found from the 2320° spectrum. Since the current through the cell under any filter for a given equal-energy radiation is proportional to the total area of the corresponding sensitivity curve in Fig. 2, the current-difference for any two filters is proportional to the corresponding difference of areas. As the curves are on a rather small scale it is more convenient to use the sums of the ordinates at 10 $m\mu$ intervals from which they were plotted. These "sensitivity integrals" are given in column 3 of the table. It is convenient to take the equal-energy

spectrum as having unit intensity at every wave-length, so that, as the ordinates are at 10 $m\mu$ intervals, the "energy integral" for this spectrum is equal to the wave-length range of the assumed block divided by 10. This is given in column 4. K_1, the ratio of column 4 to column 3, is given in column 5, and is evidently proportional to the constant by which the reading or reading-difference should be multiplied in order to find the energy in an equal-energy spectrum lying within the block that the combination is assumed to measure.

Similarly, the current or current-difference for a given combination under 2320° radiation is proportional to the corresponding area or area-difference for the 2320° response curves, i.e., to the "response integral" obtained from the ordinates, as given in column 6, and is assumed to measure the 2320° "energy-integral" for the given block, as given in column 7.

TABLE 2.

Correction for variation of energy with wave-length within each spectral block of the 2320° spectrum.

1	2	3	4	5	6	7	8	9
		Equal energy spectrum.			2320° spectrum.			
Filter or F. Diff.	Assumed Range $m\mu$.	Sensitivity integral.	Energy integral	Ratio K_1.	Response integral.	Energy integral.	Ratio K_2	Correcting factor $= \frac{K_1}{K_2}$
BG 12	360—500	1·56	14	8·97	0·174	1·485	8·53	1·05
GG 11	—	12·06	—	—	11·26	—	—	—
GG 11–RG 1	500—600	7·43	10	1·35	4·84	5·76	1·19	1·13
RG 1	—	4·63	—	—	6·42	—	—	—
RG 1–RG 8	600—700	4·07	10	2·46	5·08	13·81	2·72	0·90
RG 8	700—820	0·56	12	21·3	1·34	29·34	21·9	0·97
No Filter	360—820	19·06	46	2·41	14·14	50·4	3·56	0·68
Corn. Green	500—600	0 593	10	16·9	0·265	5·76	21·7	0 78
RG 1	600—760	4·63	16	3·45	6·42	26·82	4·19	0·82
No Filter	400—760	19·06	36	1·89	14·14	33·96	2.40	0 79

Since the sensitivity, energy, and response curves are plotted on corresponding scales, the ratio K_2, found by dividing the 2320° energy integral by the response integral, is strictly comparable with the corresponding ratio K_1 found in a similar way for the equal-energy spectrum, for which the response is equal to the sensitivity. Thus, K_1/K_2 is the ratio of the constants by which the readings should be multiplied in order to find the block energies for equal-energy and 2320° spectra, respectively. K_1/K_2 is thus the factor by which the 2320° constant, as found by the lamp, should be multiplied in order to find the corresponding energy constant for an equal-energy spectrum.

It is well to remember that, in finding the sensitivity and response integrals, the summation of ordinates must be extended over the whole range throughout

which the cell with filter is sensitive, whereas for the energy integral the summation only extends to the limits of the block that the combination is assumed to measure. Thus, the correction can only be an approximate one, quite apart from errors due to inaccuracies in the curves from which it is derived. The actual sensitivity-difference curves generally have 'tails' extending beyond the limits of the assumed block, especially on the red side. These red 'tails' become much more important in the 2320° response curves, owing to the preponderance of red light in the lamp spectrum. The 'tails' are included in the sensitivity and response integrals given in Table 2, since they contribute to the reading, and so must be considered. This means that the two energy constants for a given block give correct values for the energy within the block only if the assumed energy distribution is continued for some distance beyond the block limit, especially on the red side. This is approximately true for the lamp, but is evidently not true for daylight, for which the simplifying assumption of an equal-energy distribution within the block is, at best, a crude approximation. We could, of course, obtain a more accurate result by a method of successive approximations, applying an extension of the method to adapt the energy constants to the distribution as found approximately. The procedure would, however, be hopelessly cumbrous in practice.

It will be seen that for the ranges given in the upper part of Table 2 the values of K_1/K_2 only differ widely from unity in the case of the cell without filter. This is relatively insensitive to the large amount of long-wave radiation emitted by the lamp, and gives a more satisfactory correction factor if its reading is taken to represent a shorter range, as in the last line of the table. For the filter combinations given in the upper part of the table the factors obtained as above are sufficiently close to unity to warrant the assumption that the residual errors in the energy constants, as found by their aid, are small.

Energy Constants.

Table 3 shows the combination of the energies, as found in Table 1, with the measured cell currents or current-differences to obtain the energy constants for the radiation from the lamp, and hence by the application of the correction factors found in Table 2, for an equal-energy spectrum.

The lower parts of the three tables show an alternative method which we have sometimes used for breaking up the spectrum above 500 $m\mu$. It has the advantage of avoiding all differential measurements, but the assignment of the block 500–600 $m\mu$ to the Corning Sextant Green is rather forced, since the maximum for the selenium cell under the filter is at about 530 $m\mu$ for equal-energy or 540 $m\mu$ for 2320° radiation, and the range of sensitivity of the combination extends from well below 500 to barely 600 $m\mu$. This rather arbitrary apportionment, which is made from motives of convenience, is reflected in the correction factor, K_1/K_2, which differs appreciably from unity. RG 1, when used singly, may be taken to measure the block up to 760 $m\mu$, above which the sensitivity of the cell is relatively low. Here also, however, the lack of symmetry of the sensitivity curve causes K_1/K_2 to be rather low.

The curves for the equal-energy sensitivity and the 2320° response of the cell under the infra-red filter RG 7 are not sufficiently reliable to enable K_1/K_2 to be found from them. Since, however, the sensitivity of the cell appears to drop smoothly to zero, probably about 860 $m\mu$, and the transmission of the filter rises in a somewhat similar manner from zero at about 760 $m\mu$, it would seem that the sensitivity curve representing the product of these two variables should not be very unsymmetrical, so that the factor may without very serious error be taken as unity, as is done in Table 3.

At the foot of the tables are given the figures for the cell without filter on the assumption that its reading represents the energy in the visible spectrum from 400 to 760 $m\mu$. This is probably a fairer estimate than the longer range that may be covered with the aid of filters, owing to the relative insensitivity of the cell towards the end of its range. Equal-energy constants, however, are not well suited for the measurement of daylight by the cell without filter, as the energy distribution differs so greatly from uniformity over the wide range so covered. If the cell must be used alone it is best to adopt an energy constant obtained by comparison of the cell readings with, and without, filters under average steady daylight, using the filter constants obtained as above.

TABLE 3.

Energy Constants in microwatts per square centimetre per microampere of the photoelectric current, corrected for curvature of the light/current characteristic; obtained by comparing the energies in the spectral blocks at 40 cm. distance (see Table 1) with the corresponding currents. The reduction from 2320° spectrum constants to equal-energy constants is effected by the factors found in Table 2. The last column shows the equal-energy constants found on the assumption that the lamp is at 2360°K. on the old scale as used in the International Critical Tables.

Filter or F. Diff.	Assumed range. $m\mu$.	Energy in range μw per sq. cm.	Current or current diff. μa.	Energy Constants in μw per sq. cm. per μa.		
				2320° spectrum.	equal-energy. (*a*)	equal-energy. (*b*)
BG 12	360—500	9·04	0·444	20·35	21·4	25·4
GG 11–RG 1	500—600	35·2	10·4	3·39	3·83	4·30
RG 1–RG 8	600—700	84·4	8·84	9·55	8·6	9·35
RG 8	700—820	178·6	1·96	91·0	88	95
No Filter	360—820	307·2	23·9	12·85	8·75	9·6
Corn. Green	500—600	35·2	0·658	53·5	41·5	46·5
RG 1	600—760	163·5	10·8	15·15	12·4	13·4
RG 7	760—860	179·5	0·140	1285	1285	1380
No Filter	400—760	206·8	23·9	8·65	6·85	7·5

(*a*) Colour Temperature of lamp taken as 2320°.
(*b*) ,, ,, ,, ,, 2360°.

Effect of Differences in the Temperature Scales used.

We have assumed above that the standard lamp at a colour temperature 2360° K on the new temperature scale corresponds to 2320° on the scale represented by the figures in the International Critical Tables, 1929. As the new scale was only adopted in 1932 this seemed to be a reasonable assumption. A comparison of the energy radiated by the lamp in the visible spectrum, as estimated on this hypothesis, with the rated candlepower suggests, however, that in so doing we are underestimating the colour temperature.

Thus, by multiplying the relative energy for each wave-length of the 2320° spectrum (old scale) by the corresponding visibility factor, and dividing by the total energy (in the same units) in the visible spectrum, range 400 to 760 $m\mu$, we find that the average relative visibility of this radiation should be 0·207. If we take 668 lumens per watt as the luminous efficiency of monochromatic radiation of maximum visibility, we find that the luminous efficiency of the radiation in the range 400 to 760 $m\mu$ should be $0{\cdot}207 \times 668$, i.e., 138 l.p.w. The horizontal candlepower of the lamp is stated to be 51·05, which should correspond to a radiant power of 51·05/138, i.e., 0·370 watt per sq. radian within the range 400 to 760 $m\mu$, or 5·29 per cent. of the total radiation (7 w. per sq. rad.). As estimated above, however, only 4·765 per cent. of the total falls within this range, a discrepancy of some 10 per cent.

This discrepancy will practically disappear if we assume that the new scale agrees with that of the tables, so that the lamp temperature should be taken as 2360° for purposes of comparison, as this raises our estimate of the percentage of the total energy that lies within the given range to 5·20. Such an assumption would have the effect of raising the energy-constants for the lamp spectrum by amounts ranging from 8 per cent. for the red filters to 19 per cent. for the blue. The effect on the correction factors for the reduction of the constants from the lamp spectrum to the equal-energy spectrum, as calculated in Table 2, is probably small enough to be neglected, so that we may apply the same correcting multipliers to the equal-energy constants to allow for this modified estimate of the colour temperature of the lamp. The corrected constants thus found are given in the last column of Table 3. As the results obtained by their use are more consistent with the recognised luminous efficiencies both of the lamp and of daylight we have decided to adopt them provisionally, pending further investigations.

Application to the Measurement of Daylight.

The figures in Table 4 show the results of applying the constants given in the last column of Table 3 to some daylight readings made on the roof of the Royal Dublin Society's buildings at Ball's Bridge, about 2 miles S.E. of the centre of Dublin. The exposure to the sky was almost perfect, and there was little apparent local smoke. The readings of vertical sunlight were made by difference, by observing alternately the total radiation and that with the sun

screened off by a small object at a distance of a couple of metres from the cell, the latter reading giving the diffuse radiation. The observed currents were corrected for the 'curvature' error of the cell (6) and for the effect of obliquity in increasing the reflection loss at the polished upper surface of the opal glass (5). These corrected currents, when multiplied by the appropriate constants as found above, gave the energy per second per square centimetre in the various spectral blocks. By adding these we get the total power per sq. cm. in the range 360–760 $m\mu$, which, when combined with the corrected current for the cell without filter, gives the constant for the latter for that range and the particular spectral distribution involved.

TABLE 4.

Some daylight measurements.

June 4, 1934, *about G.M. Noon.* Vertical Daylight. Sun through very slight cirrus haze. Sky blue.

Filter	Range	Power in Range (*mw* per sq. cm.)			Spectral Power Density (μw per sq. cm. per $m\mu$)		
	$m\mu$	Sun	Sky	Total	Sun	Sky	Total
BG 12	360–500	10·6	5·0	15·6	76	35·5	111·5
Corn. Green	500–600	8·2	2·35	10·55	82	23·5	105·5
RG 1	600–760	12·8	2·05	14·85	80	13	93
No Filter	360–760	31 6	9·4	41·0			
Constant	360–760	6·45	6·92	6·55 μw per sq. cm. per μa.			

June 11, 1934, *about* 11.30 *a.m. G.M.T.* Perpendicular Sunlight measured with cell mounted in a telescope tube directed towards the sun and only exposed to a small solid angle (about 30 square degrees) surrounding and including the sun's disc. Sun through light cirrus haze.

Filter	Range	Power in Range (*mw* per sq. cm.)	Spectral Power Density (μw per sq. cm. per $m\mu$)
BG 12	360–500	9·9	70·6
Corn. Green	500–600	8·95	89·5
RG 1	600–760	12·1	75·5
No Filter	360–760	30·95	
Constant	360–760	6·45 μw per sq. cm. per μa.	

The above constants for the cell without filter are for the range 360–760 obtained by summing the three ranges with filters. To derive the corresponding constants for the range 400–760 we must subtract the power below 400 $m\mu$. We find from Abbot's figures for mean noon sunlight at Washington, as quoted by Davis and Gibson (3) that some 4 per cent. of the power in the range 360–760 $m\mu$ lies between 360 and 400. From a comparison of the relative proportions of sunlight and sky light transmitted by the various filters we estimate that the corresponding figure for our blue sky light cannot have been very far from 15 per cent. We thus find that the constants for the cell without filter for the range 400–760 $m\mu$ reduce to 6·2 and 5·9 microwatts per sq. cm. per microampere for sunlight and blue sky light, respectively.

We should expect the constant for sunlight to be lower than the equal-energy constant 7·5, since the maximum intensity of sunlight occurs at a wave-length not very far from that of the maximum sensitivity of the cell. We should hardly, however, expect the discrepancy to be so large, and it is even more surprising to get such a low constant for blue sky light, to which the cell should be relatively insensitive.

Another surprising result is the high value that these constants give for the luminous efficiency of daylight. As a result of standardisation of the cell with the standard lamp and Davis Gibson artificial mean noon sunlight filter we have found that for the cell under opal glass but without filter 1 μa corresponds to 16·4 lux, and we have elsewhere (2) given evidence that the scale so obtained does not differ very widely from the visible scale for mixed daylight. If, however, we combine the photometric constant 16·4 lux with the power constant 6·1 microwatts per sq. cm., which we may take as the mean for mixed light, we get a luminous efficiency as high as 269 lumens per watt for the range 400–760 $m\mu$, as compared with the figure 223 l.p.w., which we find for Abbot's mean noon sunlight using the International Visibility Factor curve and assuming a maximum luminous efficiency of 668 l.p.w. The discrepancy would have been even more serious if we had used the constants obtained on the assumption that the standard lamp had a colour temperature of 2320° K on the old scale.

The relative proportions of energy in the red and blue parts of the sunlight spectrum are intermediate between those found for Abbot's mean noon sunlight and his June noon sunlight. This is natural, since the noon altitude of the summer sun in Dublin is less than that of the summer sun, but greater than the annual mean, for Washington. The ratio of green to red for our perpendicular sunlight is about the same as for Abbot's mean noon sunlight, but in our measurement of the vertical sunlight obtained by difference on another day the green is relatively between 10 and 15 per cent. low.

It is, perhaps, worth recording that at 12.47 p.m. on June 4, about 35 minutes after the conclusion of the measurements of vertical light recorded above, a Moll Solarimeter recorded 70·6 and 14·1 mw. per sq. cm. for the total vertical radiation from sun and sky, respectively. If we combine these with the

figures obtained above with the cell, namely, 31·6 and 9·4, we find that 45 per cent. of the solar radiation and 67 per cent. of the sky radiation lay in the range 360–760 $m\mu$.

On June 11, at 11.7 a.m., shortly before the measurements of perpendicular sunlight, the solarimeter recorded 57·9 mw. for the vertical solar radiation. As the sun's altitude was about 57°, this would correspond to about 69·2 mw. on a normal surface. Comparing this with the figure 30·95 given above, we again get 45 per cent. of the total energy as being within the range 360–760.

Conclusion.

It is evident from the discrepancies to which attention has been called that the constants found as above may contain errors, possibly of the order of 20 per cent. Further measurements, both with the lamp and in daylight, may reduce the uncertainties, but it does not seem likely that any high degree of accuracy will be attained by such means.

The method suffers from two major objections. (*a*) The spectrum of the standard lamp is widely different from that of the light which the cell is used to measure, and is very deficient towards the violet end. (*b*) The results are much affected by errors in the assumed colour temperature of the source.

It, however, enables the various combinations of cell and filters to be standardised approximately in energy units with comparatively simple apparatus.

Ångström (1) has suggested a method of standardisation based on pyrheliometer measurements of sunlight with suitable filters. This would possess the great advantage of using a standardising source approximately similar in spectral composition to the radiation to be measured. It remains to be seen, however, whether the pyrheliometer measurements will enable the variations in the spectral distribution of sunlight at different times and in different places to be estimated with sufficient accuracy to enable this method to be used with confidence.

Summary.

A method is described for the standardisation of photo-electric cells with colour filters for the measurement of the energy in different parts of the spectrum. This is effected by means of a standard tungsten filament lamp at a rated colour temperature of 2360° K.

The calculation of the radiant power or energy per second in various spectral blocks isolated by means of the filters is considered in detail, and from the resulting currents, corrected for the 'curvature' error of the rectifier cell used, the constants for the various spectral regions are obtained.

The effect of uncertainties in the temperature scale adopted is considered.

An application of the constants so obtained to some daylight readings shows certain anomalies which suggest that further investigation of the method is desirable.

The method is a comparatively simple one for the approximate standardisation of photo-electric cells in power units, but owing to the relatively low temperature of the standardising source and some uncertainties as to the scale the results so far obtained may possibly contain errors as large as 20 per cent.

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No. 39.

A CONTRIBUTION TO KNOWLEDGE OF THE IRISH FUNGI.

By P. O'CONNOR, A.R.C.Sc.I., B.Sc., Ph.D.

[Read June 23. Published September 17, 1936.]

The accompanying list of fungi is the result of an attempt to extend the knowledge of the occurrence and distribution of members of that group in Ireland. With the exception of a few cases where more exact information than is already available seems desirable, the species here enumerated do not appear to have been recorded hitherto for the county-divisions in which their occurrence is noted. Though a few of my gatherings have already been published elsewhere[1] I think it desirable, in order to avoid the necessity of consulting smaller or special lists, to include them here.

The sequence of the arrangement and the classification adopted for the various groups are mainly as follows:—

Basidiomycetes.

Aphyllophorales, Exobasidiales and Auriculariales.—Carleton Rea: British Basidiomycetae, 1922;

Uredinales.—W. B. Grove: The British Rust Fungi, 1913;

Ustilaginales.—G. Massee: Mildews, Rusts and Smuts, 1913.

Ascomycetes.

Plectomycetes.—G. Massee: Mildews, Rusts and Smuts, 1913;

Pyrenomycetes.—Rabenhorst: Kryptogamenflora, 1884–87;

Hysteriales.—Rabenhorst: Kryptogamenflora, 1887–96;

Discomycetes, including Exoascales.—G. Massee: British Fungus Flora, IV, 1895;

Hemiasceae.

Phycomycetes.—Rabenhorst: Kryptogamenflora, 1892.

Fungi Imperfecti.—Rabenhorst: Kryptogamenflora, 1901–10, in part modified according to W. B. Grove: The British Coelomycetes, 1935.

The order of the records follows the plan adopted in Praeger, Irish Topographical Botany, 1901. For the date of collection, only the month and the

[1] Lillian M. Hunter: The Genus *Milesia* in Great Britain and Ireland: Trans. Br. Myc. Soc., xx, 116.

year are given. The names of species which appear to be recorded here for the first time for Ireland are preceded by an asterisk (*); two asterisks (**) are used to indicate species which seem to be new to the British flora. The names of persons which sometimes are added after the dates are those of collectors who helped me by contributing specimens of the corresponding species. To all these I beg to offer thanks for their kindly assistance.

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BASIDIOMYCETES.

Aphyllophorales.

Polyporus intybaceus Fr.
on base of *Quercus Robur*: Powerscourt, Wicklow, 11/'31.

Polyporus sulphureus Fr.
on *Quercus Robur*: Killarney, Kerry, 6/'35;
on *Prunus avium*: Newgrange, Meath, 6/'35.

Polyporus squamosus Fr.
on wood: Castleblayney, Monaghan, 6/'35.

Fomes annosus Fr.
on *Cupressus sempervirens*: Kenmare, Kerry, 12/'34.

Polystictus versicolor Fr.
on *Betula alba*: Kenmare, Kerry, 12/'34;
on *Fagus sylvatica*: Castleblayney, Monaghan, 6/'35.

Irpex obliquus Fr.
on *Betula alba*: nr. Waterford, 6/'35.

Trametes gibbosa Fr.
on wood: Kilmacurragh, Wicklow, 10/'32.

Clavaria vermicularis Fr.
on soil: Tibradden, Dublin, 9/'34.

Clavaria inaequalis (Müll.) Quél.
on soil: Blackstairs, Carlow, 10/'33: Dr. M. O'Leary.

**Microstroma album* (Desm.) Sacc.
on *Quercus Robur*: Powerscourt, Wicklow, 10/'33;
on *Q. cerris*: Malahide, Dublin, 10/'32.

***Asterostroma ochroleuca* Bres.
on wood, indoors: Ardnacrusha, Clare, 6/'31: Miss L. P. Gwynn.

Exobasidiales.

**Exobasidium Rhododendri* Cramer on *Rhododendron* sp.:	Moville, Donegal, 7/'33: Rev. Jos. McCorkell.

Auriculariales.

Auricularia auricula-Judae (L.) Schroet.

on wood:	Athlone, Westmeath, 7/'34;
on wood:	Castleblayney, Monaghan, 6/'35.

Uredinales.

The symbols I, II, and III, preceding the name of the host in this group, denote respectively the aecidial, uredo, and teleuto stages of the corresponding fungus.

Uromyces Valerianae Fckl.

II on *Valeriana sambucifolia*:	Farnanes, Cork, 8/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II & III on *V. officinalis*:	Clonsilla, Dublin, 10/'32;
II on do.	Mullingar, Westmeath, 7/'35.

Uromyces Scrophulariae Fckl.

I & III on *Scrophularia nodosa*:	Scarriff, Clare, 7/'33;
III on do.	Enniskerry, Wicklow, 7/'33;
II & III on *S. aquatica*:	Corrib, Galway, 7/'34.

Uromyces Trifolii Lév.

II & III on *Trifolium repens*:	Blessington, Wicklow, 7/'35;
II & III on *T. pratense*:	Stillorgan, Dublin, 10/'34.

Uromyces striatus Schröt.

II on *Medicago lupulina*:	Ring, Waterford, 10/'33.

Uromyces Loti Blytt.

II on *Lotus corniculatus*:	Ring, Waterford, 10/'33;
II on do.	Recess, Galway, 7/'35.

Uromyces Fabae de Bary

II on *Vicia sepium*:	Killarney, Kerry, 6/'35;
II on do.	Farnanes, Cork, 8/'33;
II on do.	Ring, Waterford, 10/'33;
II on do.	Scarriff, Clare, 7/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Courtown, Wexford, 6/'35;
II on do.	Poulaphouca, Kildare: 8/'33;

Uromyces Fabae de Bary—*continued.*

II & III on *Vicia sepium*:	Avondale, Wicklow, 10/'32;
II & III on *Lathyrus pratensis*:	Killiney, Dublin, 10/'32;
II on *V. sepium*:	Dowth, Meath, 7/'33;
II & III on do.	Belturbet, Cavan, 6/'35;
II on do.	Boyne Valley, Louth, 7/'33.

**Uromyces tuberculatus* Fckl.

II & III on *Euphorbia hiberna*:	Killarney, Kerry, 7/'34: Dr. R. L. Praeger;
II & III on do.	Keamaneigh, Cork, 6/'35.

Uromyces Geranii Otth. et Wart.

II on *Geranium pyrenaicum*:	Glencree, Wicklow, 7/'35: J. P. Brunker;
II & III on do.	Rush, Dublin, 6/'35: Dr. M. O'Leary.

Uromyces Ficariae Lév.

III on *Ranunculus Ficaria*:	Carton, Kildare, 5/'35;
III on do.	The Dargle, Wicklow, 4/'35.

Uromyces Betae Lév.

II & III on *Beta maritima*:	Killiney, Dublin, 10/'32.

Uromyces Rumicis Wint.

II on *Rumex conglomeratus*:	Farnanes, Cork, 8/'33;
II on *R. obtusifolius*:	Courtown, Wexford, 6/'35;
II on do.	Corrib, Galway, 7/'34;
II & III on *R. crispus*:	Sutton, Dublin, 11/'32;
II on do.	Boyne Valley, Meath, 7/'33;
II & III on *R. obtusifolius*:	Castleblayney, Monaghan, 6/'35.

Uromyces Polygoni Fckl.

III on *Polygonum aviculare*:	Greenhills, Dublin, 10/'34;
II & III on do.	Athlone, Westmeath, 7/'35.

Uromyces Scillarum Wint.

III on *Scilla non-scripta*:	Courtown, Wexford, 6/'35;
III on do.	Lambay, Dublin, 6/'32;
III on do.	Castleblayney, Monaghan, 6/'35.

Uromyces Dactylidis Otth.

II & III on *Dactylis glomerata*:	Carrickmines, Dublin, 12/'32.

Uromyces Poae Raben.

I on *Ranunculus Ficaria*:	Kenmare, Kerry, 3/'34;
I on do.	Tramore, Waterford, 3/'34;
I on do.	Adare, Limerick, 3/'34;
I on do.	Dromineer, Tipperary, 4/'33;
I on *R. repens*:	Carton, Kildare, 5/'35;
I on *R. Ficaria*:	Kilmacud, Dublin, 4/'32;
I on do.	Dunboyne, Meath, 6/'34;
I on *R. repens*:	Athlone, Westmeath, 7/'35;
I on *R. acris*:	Belturbet, Cavan, 6/'35;
I on *R. repens*:	Castleblayney, Monaghan, 6/'35.

Puccinia expansa Link

III on *Senecio Jacobaea*:	Ballycorus, Dublin, 6/'36.

Puccinia Centaureae DC.

II & III on *Centaurea nigra*:	Ring, Waterford, 10/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Cahore, Wexford, 7/'35: Prof. J. Doyle;
II & III on do.	Killedmond, Carlow, 10/'34: Dr. M. O'Leary;
II & III on do.	Leixlip, Kildare, 7/'33;
II & III on do.	Malahide, Dublin, 10/'32.

**Puccinia Cardui-pycnocephali* Syd.

II & III on *Carduus pycnocephalus*:	Malahide, Dublin, 7/'35.

Puccinia Cirsii Lasch.

II & III on *Cnicus pratensis*:	Killiney, Dublin, 9/'34.

Puccinia obtegens Tul.

II on *Cnicus pratensis*:	Ring, Waterford, 10/'33;
II & III on *C. arvensis*:	Birchfield, Kilkenny, 10/'33;
II & III on do.	Courtown, Wexford, 6/'35;
II on do.	Corrib, Galway, 7/'34;
II & III on do.	Malahide, Dublin, 10/'32;
II & III on do.	Mullingar, Westmeath, 7/'35;
II on do.	Belturbet, Cavan, 6/'35;
II on do.	Drogheda, Louth, 7/'33;
II on do.	Castleblayney, Monaghan, 6/'35.

Puccinia Lapsanae Fckl.

II & III on *Lapsana communis*:	Farnanes, Cork, 8/'33;
II & III on do.	Scarriff, Clare, 7/'33;
II & III on do.	Courtown, Wexford, 6/'35;
II & III on do.	Corrib, Galway, 7/'34;
I on do.	Whitehall, Dublin, 5/'34;
II & III on do.	Malahide, Dublin, 10/'32;
II & III on do.	Belturbet, Cavan, 6/'35.

Puccinia Hypochaeridis Oud.

II on *Hypochaeris radicata*:	Glengarriff, Cork, 6/'35;
II & III on do.	Maynooth, Kildare, 7/'33;
II on do.	Devil's Glen, Wicklow, 6/'34;
II & III on do.	Glenasmole, Dublin, 11/'32.

Puccinia Taraxaci Plow.

II on *Taraxacum vulgare*:	Ring, Waterford, 10/'33;
II & III on do.	Cashel, Tipperary, 6/'35;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Courtown, Wexford, 6/'35;
II on do.	Corrib, Galway, 7/'34;
II & III on do.	Celbridge, Kildare, 8/'33;
II on do.	The Murrough, Wicklow, 7/'33;
II & III on do.	Malahide, Dublin, 10/'32;
II on do.	Dowth, Meath, 7/'33;
II & III on do.	Mullingar, Westmeath, 7/'35;
II on do.	Belturbet, Cavan, 6/'35;
II on do.	Boyne Valley, Louth, 7/'33;
II & III on do.	Castleblayney, Monaghan, 6/'35.

Puccinia Sonchi Rob.

II on *Sonchus oleraceus*:	Killarney, Kerry, 12/'34;
II & III on *S. arvensis*:	Ring, Waterford, 10/'33;
II & III on *S. oleraceus*:	Scarriff, Clare, 7/'33;
II on *S. arvensis*:	Nenagh, Tipperary, 7/'33;
II on do.	Birchfield, Kilkenny, 10/'33;
II on *S. asper*:	Courtown, Wexford, 6/'35;
II on *S. oleraceus*:	Corrib, Galway, 7/'34;
II on do.	Avondale, Wicklow, 10/'32;
II & III on do.	Carrickmines, Dublin, 10/'32;
II on do.	nr. Cavan, 7/'35.

Puccinia Crepidis Schröt.

I on *Crepis virens*:	Scarriff, Clare, 7/'33.

Puccinia major Dietel.

I on *Crepis paludosa*:	Leixlip, Kildare, 6/'33;
II & III on do.	Leixlip, Kildare, 7/'33.

Puccinia punctata Link

II & III on *Galium saxatile*:	Ring, Waterford, 10/'33;
II on *G. verum*:	Ballybrittas, Leix, 7/'33;
II & III on do.	Killiney, Dublin, 10/'32.

Puccinia Antirrhini Diet. et Holw.

III on *Antirrhinum majus*:	Howth, Dublin, 7/'35.

Puccinia Veronicae Schröt.

III on *Veronica montana*:	Enniskerry, Wicklow, 7/'33.

Puccinia Menthae P.

II & III on *Mentha aquatica*:	Kenmare, Kerry, 12/'34;
II & III on do.	Farnanes, Cork, 8/'33;
II & III on do.	Ring, Waterford, 10/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Corrib, Galway, 7/'34;
II & III on do.	Enniskerry, Wicklow, 7/'33;
II & III on do.	Knocksedan, Dublin, 11/'32;
II & III on do.	nr. Cavan, 7/'35.

Puccinia Glechomatis DC.

III on *Nepeta hederacea*:	Kenmare, Kerry, 12/'34;
III on do.	Celbridge, Kildare, 9/'34;
III on do.	Carrickmines, Dublin, 10/'32.

Puccinia annularis Schlecht.

III on *Teucrium Scorodonia*:	Borris, Carlow, 10/'33: Dr. M. O'Leary.

Puccinia Hydrocotyles Cooke

II on *Hydrocotyle vulgaris*:	Farnanes, Cork, 8/'33;
II on do.	Dingle, Dublin, 10/'32.

Puccinia Saniculae Grev.

I on *Sanicula europaea*:	Killarney, Kerry, 6/'35;
II & III on do.	Parknasilla, Kerry, 4/'34;
II & III on do.	Puckane, Tipperary, 4/'33;
I on do.	Courtown, Wexford, 6/'35;
I & II on do.	Dowth, Meath, 7/'33.

Puccinia tumida Grev.

II & III on *Conopodium majus*:	Kenmare, Kerry, 3/'34;
III on do.	Powerscourt, Wicklow, 4/'34.

Puccinia Chaerophylli Purt.
II & III on *Anthriscus sylvestris*: Birchfield, Kilkenny, 10/'33;
II & III on do. Dowth, Meath, 7/'33.

Puccinia Conii Fckl.
II on *Conium maculatum*: Farnanes, Cork, 6/'35;
II on do. Courtown, Wexford, 6/'35;
II on do. Belturbet, Cavan, 6/'35.

Puccinia Smyrnii Cord.
III on *Smyrnium Olusatrum*: Cobh, Cork, 6/'35;
III on do. Cappoquin, Waterford, 6/'35;
I on do. Powerscourt, Wicklow, 4/'32;
I & III on do. Ballyboden, Dublin, 12/'32.

Puccinia Circaeae Pers.
III on *Circaea lutetiana*: Birchfield, Kilkenny, 10/'33;
III on do. Borris, Carlow, 10/'33: Dr. M. O'Leary;
III on do. Corrib, Galway, 7/'34.

**Puccinia pulverulenta* Grev.
I & II on *Epilobium hirsutum*: Cahore, Wexford, 7/'35: Prof. J. Doyle;
I, II & III on do. Nenagh, Tipperary, 7/'33;
I, II & III on do. Leixlip, Kildare, 7/'33;
I, II & III on *E. palustre*: Dingle, Dublin, 6/'33.

Puccinia Epilobii DC.
II & III on *Epilobium montanum*: Glengarriff, Cork, 6/'35;
II & III on *E. hirsutum*: Birchfield, Kilkenny, 10/'33;
III on *E. obscurum*: Castleblayney, Monaghan, 6/'35.

Puccinia Violae DC.
III on *Viola Riviniana*: Kenmare, Kerry, 12/'34;
II & III on *V. hirta*: Farnanes, Cork, 8/'33;
II & III on *V. Riviniana*: Ring, Waterford, 10/'33;
I on do. Headford, Galway, 7/'34;
II & III on do. Poulaphouca, Kildare, 8/'33;
II & III on *V. hirta*: Enniskerry, Wicklow, 7/'33;
I on *V. Riviniana*: Killakee, Dublin, 4/'33;
II & III on *V. sylvestris*: Raheny, Dublin, 10/'32;
I on *V. Riviniana*: Dunboyne, Meath, 6/'34;
II & III on *V. odorata*: Boyne Valley, Louth, 7/'33.

Puccinia Buxi DC.
III on *Buxus sempervirens*: Ring, Waterford, 10/'33.

Puccinia Malvacearum Mont.

III on *Malva sylvestris*:	Cobh, Cork, 6/'35;
III on do.	Ring, Waterford, 10/'33;
III on do.	Cashel, Tipperary, 6/'35;
III on do.	Celbridge, Kildare, 6/'35;
III on do.	Malahide, Dublin, 10/'32;
III on do.	Dunboyne, Meath, 6/'34;
III on do.	Athlone, Westmeath, 7/'35;
III on do.	Belturbet, Cavan, 6/'35;
III on do.	Boyne Valley, Louth, 7/'33.

Puccinia Umbilici Guep.

III on *Cotyledon Umbilicus*:	Sneem, Kerry, 4/'34;
III on do.	Gougane Barra, Cork, 6/'35;
III on do.	Tramore, Waterford, 3/'34;
III on do.	Coolyhune, Carlow, 3/'35: Dr. M. O'Leary;
III on do.	Ireland's Eye, Dublin, 6/'32.

Puccinia Chrysosplenii Grev.

III on *Chrysosplenium oppositifolium*:	Killakee, Dublin, 10/'33.

Puccinia mirabilissima Peck.

II & III on *Berberis Mahonia*:	Carton, Kildare, 4/'36;
II & III on do.	Milltown, Dublin, 2/'35.

Puccinia Calthae Link

II & III on *Caltha palustris*:	Scarriff, Clare, 7/'33;
II & III on do.	Nenagh, Tipperary, 7/'33;
II & III on do.	Corrib, Galway, 7/'34.

Puccinia Lychnidearum Link

III on *Stellaria uliginosa*:	Dingle, Dublin, 10/'32;
III on *Lychnis dioica*:	Castleblayney, Monaghan, 6/'35.

Puccinia Acetosae Körn.

II on *Rumex Acetosa*:	Kenmare, Kerry, 3/'34.

Puccinia Polygoni-amphibii Pers.

II & III on *Polygonum Persicaria*:	Birchfield, Kilkenny, 10/'33;
II & III on do.	Poulaphouca, Kildare, 8/'33;
II on *P. amphibium*:	The Murrough, Wicklow, 7/'33;
II & III on *P. Persicaria*:	Howth, Dublin, 7/'33.

Puccinia Porri Wint.

II & III on *Allium vineale*:	Killarney, Kerry, 6/'35;
II & III on do.	Portmarnock, Dublin, 7/'34: Mrs. Hall.

Puccinia obscura Schröt.
II on *Luzula sylvatica*: Enniskerry, Wicklow, 5/'33;
I on *Bellis perennis*: Howth, Dublin, 10/'34.

Puccinia Caricis Reb.
I on *Urtica dioica*: Dromineer, Tipperary, 4/'33;
I on do. Turraun, Offaly, 4/'33;
I on do. Carton, Kildare, 5/'35;
I on do. Powerscourt, Wicklow, 5/'34;
II & III on *Carex pendula*: Powerscourt, Wicklow, 4/'32;
I on *U. dioica*: Castleblayney, Monaghan, 6/'35.

Puccinia Pringsheimiana Kleb.
I on *Ribes Grossularia*: Galway, 6/'35: Prof. T. Dinan.

Puccinia dioicae Magn.
I on *Cnicus palustris*: Killegar, Wicklow, 7/'34;
I on do. Recess, Galway, 7/'35.

Puccinia graminis Pers.
II & III on *Alopecurus pratensis*: Ring, Waterford, 10/'33;
III on *Agrostis tenuis*: Greystones, Wicklow, 9/'34.

Puccinia Lolii Nielsen
I on *Rhamnus catharticus*: Lanesboro', Longford, 6/'33: Dr. R. L. Praeger.

**Puccinia Festucae* Plowr.
I on *Lonicera Periclymenum*: Courtown, Wexford, 6/'35.

Puccinia sessilis Schneid.
II on *Phalaris arundinacea*: Birchfield, Kilkenny, 10/'33;
II & III on do. Knocksedan, Dublin, 11/'32.

Puccinia Orchidearum-Phalaridis Kleb.
I on *Orchis elodes*: Ballyman Glen, Dublin, 7/'35;
I on do. Mullingar, Westmeath, 7/'35.

Puccinia Phragmitis Körn.
II & III on *Phragmites communis*: Waterville, Kerry, 8/'33: Dr. M. O'Leary.

Puccinia Poarum Niels.
I on *Tussilago Farfara*: Farnanes, Cork, 8/'33;
I on do. Ring, Waterford, 10/'33;
I on do. Scarriff, Clare, 7/'33;
I on do. Birchfield, Kilkenny, 10/'33;
I on do. Courtown, Wexford, 6/'35;
I on do. Dowth, Meath, 7/'33;
I on do. Mullingar, Westmeath, 7/'35;
I on do. Belturbet, Cavan, 6/'35;
I on do. Boyne Valley, Louth, 7/'33.

Puccinia Baryi Wint.

II on *Brachypodium sylvaticum*:	Courtown, Wexford, 6/'35;
II on do.	Ballybrittas, Leix, 7/'33;
II on do.	Celbridge, Kildare, 9/'34;
II on do.	Raheny, Dublin, 10/'32;
II on do.	Boyne Valley, Louth, 7/'33.

Triphragmium Ulmariae Wint.

II & III on *Spiraea Ulmaria*:	Killarney, Kerry, 6/'35;
II & III on do.	Farnanes, Cork, 8/'33;
II & III on do.	Ring, Waterford, 10/'33;
II & III on do.	Scarriff, Clare, 7/'33;
II on do.	Nenagh, Tipperary, 7/'33;
II & III on do.	Ballybrittas, Leix, 7/'33;
III on do.	Poulaphouca, Kildare, 8/'33;
II on do.	Newcastle, Wicklow, 5/'35; Dr. M. O'Leary;
II on do.	Belturbet, Cavan, 6/'35.

Phragmidium Fragariastri Schröt.

II & III on *Potentilla sterilis*:	Killarney, Kerry, 6/'35;
II & III on do.	Courtown, Wexford, 6/'35;
II & III on do.	Recess, Galway, 7/'34;
II on do.	Bohernabreena, Dublin, 5/'33;
II & III on do.	nr. Cavan, 7/'35.

Phragmidium Potentillae Karst.

II on *Potentilla procumbens*:	Killarney, Kerry, 9/'34: Dr. R. L. Praeger.

Phragmidium Sanguisorbae Schröt.

II & III on *Poterium Sanguisorba*:	Feltrim, Dublin, 5/'33.

Phragmidium disciflorum James

II & III on *Rosa canina*:	Scarriff, Clare, 7/'33;
II & III on do.	Portroe, Tipperary, 7/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Courtown, Wexford, 6/'35;
II & III on do.	nr. Cavan, 7/'35.

Phragmidium violaceum Wint.

II & III on *Rubus fruticosus*:	Ballinskelligs, Kerry, 8/'33: Dr. M. O'Leary;
II & III on do.	Gougane Barra, Cork, 6/'35;
II & III on do.	Farnanes, Cork, 8/'33;
II & III on do.	Ring, Waterford, 10/'33;
II & III on do.	Adare, Limerick, 3/'34;

Phragmidium violaceum Wint.—*continued.*

II & III on *Rubus fruticosus*:	Scarriff, Clare, 7/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II & III on do.	Courtown, Wexford, 6/'35;
II & III on do.	Recess, Galway, 7/'34;
II & III on do.	Turraun, Offaly, 4/'33;
II & III on do.	Maynooth, Kildare, 7/'33;
II & III on do.	Boyne Valley, Meath, 7/'33;
II & III on do.	Boyne Valley, Louth, 7/'33;
II & III on do.	Castleblayney, Monaghan, 6/'35.

Phragmidium Rubi-idaei Karst.

II & III on *Rubus Idaeus*:	Farnanes, Cork, 8/'33;
III on do.	Avondale, Wicklow, 10/'32;
I on do.	Castleblayney, Monaghan, 6/'35.

Kuehneola albida (Kuehn.) Magn.

II & III on *Rubus fruticosus*:	Avondale, Wicklow, 10/'32.

Gymnosporangium clavariaeforme DC.

I on *Crataegus Oxyacantha*:	Ballyshannon, Donegal, 1898: H. C. Hart.

Coleosporium Senecionis Fr.

II on *Senecio vulgaris*:	Kenmare, Kerry, 3/'34;
II on do.	Farnanes, Cork, 8/'33;
II on do.	Ring, Waterford, 10/'33;
II on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Recess, Galway, 7/'34;
II on do.	Edenderry, Offaly, 7/'34: J. P. Brunker;
I on *Pinus Laricio*:	Powerscourt, Wicklow, 4/'35;
II on *S. vulgaris*:	Belturbet, Cavan, 6/'35;
II on do.	Drogheda, Louth, 7/'33.

Coleosporium Tussilaginis Tul.

II on *Tussilago Farfara*:	Farnanes, Cork, 8/'33;
II on do.	Ring, Waterford, 10/'33;
II on do.	Scarriff, Clare, 7/'33;
II on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Boyne Valley, Louth, 7/'33.

Coleosporium Petasitis Lév.

II on *Petasites ovatus*:	Birchfield, Kilkenny, 10/'33;
II on do.	Boyne Valley, Meath, 7/'33.

Coleosporium Sonchi Lév.

II on *Sonchus arvensis*:	Poulaphouca, Kildare, 8/'33.

Coleosporium Euphrasiae Wint.
II on *Euphrasia officinalis* and *Rhinanthus Crista-galli*: Farnanes, Cork, 8/'33;
II on *Rhinanthus minor* and *Bartsia Odontites*: Scarriff, Clare, 7/'33;
II on *Rhinanthus minor*: Dromineer, Tipperary, 7/'33;
II on *Bartsia Odontites*: Recess, Galway, 7/'34;
II & III on *Euphrasia officinalis*: Poulaphouca, Kildare, 8/'33;
II & III on do. Mullingar, Westmeath, 7/'35;
II on *Rhinanthus minor* and *Bartsia Odontites*: Boyne Valley, Louth, 7/'33.

Melampsora Larici-epitea Kleb.
II & III on *Salix viminalis*: Knockmaroon, Dublin, 10/'32;
II on do. nr. Cavan, 7/'35.

Melampsora Orchidi-repentis Kleb.
I on *Gymnadenia conopsea*: Ballyman Glen, Dublin, 7/'35.

Melampsora Larici-populina Kleb.
II & III on *Populus nigra*: Dollymount, Dublin, 10/'32.

Melampsora Euphorbiae Cast.
II & III on *Euphorbia hiberna*: Killarney, Kerry, 6/'35;
II on *E. peplus*: Farnanes, Cork, 8/'33;
II on do. Ring, Waterford, 10/'33;
II & III on do. Birchfield, Kilkenny, 10/'33;
II on do. Donnybrook, Dublin, 10/'32;
II & III on do. Belturbet, Cavan, 6/'35.

Melampsora Hypericorum Wint.
I on *Hypericum Androsaemum*: Kenmare, Kerry, 3/'34;
I on do. Glengarriff, Cork, 6/'35;
I on do. Farnanes, Cork, 8/'33;
I on *H. quadratum*: Ring, Waterford, 10/'33;
I on *H. Androsaemum*: Scarriff, Clare, 7/'33;
I on *H. dubium*: Birchfield, Kilkenny, 10/'33;
I on *H. Androsaemum*: Recess, Galway, 7/'34.

Melampsora Lini Desm.
II on *Linum catharticum*: Portroe, Tipperary, 7/'33.

**Melampsoridium Alni* (Thüm.) Diet.
II on *Alnus rotundifolia*: Dunboyne, Meath, 11/'35.

Melampsoridium betulinum Kleb.
II on *Betula alba*: Glengarriff, Cork, 6/'35.

Melampsorella Caryophyllacearum Schröt.

II on *Cerastium vulgatum*:	Mallow, Cork, 6/'35;
II on *Stellaria Holostea*:	Glenealy, Wicklow, 1/'33;
II on *C. vulgatum*:	Castleblayney, Monaghan, 6/'35.

**Pucciniastrum Agrimoniae* Tranz.

II on *Agrimonia Eupatoria*:	Ring, Waterford, 10/'33;
II on do.	Clonsilla, Dublin, 10/'32.

Thecopsora Vacciniorum Karst.

II on *Vaccinium Myrtillus*:	Farnanes, Cork, 8/'33;
II on do.	Avondale, Wicklow, 10/'32;
II on do.	Cruagh, Dublin, 10/'33.

Milesia Polypodii B. White

II & III on *Polypodium vulgare*:	Kenmare, Kerry, 3/'34;
II on do.	Gougane Barra, Cork, 6/'35;
II on do.	Courtown, Wexford, 6/'35;
II & III on do.	Glenealy, Wicklow, 1/'33;
II on do.	Castleblayney, Monaghan, 6/'35.

Milesia Scolopendrii (Fuck.) Arth.

II & III on *Phyllitis Scolopendrium*:	Kenmare, Kerry, 3/'34;
II on do.	Glengarriff, Cork, 6/'35;
II & III on do.	Tramore, Waterford, 3/'34;
II on do.	Adare, Limerick, 3/'34;
II on do.	Scarriff, Clare, 7/'33;
II & III on do.	Puckane, Tipperary, 4/'33;
II & III on do.	Birchfield, Kilkenny, 10/'33;
II on do.	Courtown, Wexford, 6/'35;
II & III on do.	Dunboyne, Meath, 6/'34;
II on do.	Mullingar, Westmeath, 7/'35;
II on do.	Boyne Valley, Louth, 7/'33;
II on do.	Castleblayney, Monaghan, 6/'35.

**Milesia murariae* (Mag.) Faull.

II on *Asplenium Ruta-muraria*:	Gougane Barra, Cork, 6/'35;
II on do.	Scarriff, Clare, 7/'33;
II on do.	Carton, Kildare, 5/'35;
II on do.	Powerscourt, Wicklow, 5/'34;
II on do.	Knocksedan, Dublin, 10/'32;
II on do.	Dowth, Meath, 7/'33;
II on do.	Boyne Valley, Louth, 7/'33;
II on do.	Castleblayney, Monaghan, 6/'35.

Milesia Blechni (Syd.) Arth.

II & III on *Blechnum Spicant*:	Parknasilla, Kerry, 4/'34;
II on do.	Farnanes, Cork, 8/'33;
II & III on do.	Ballyarthur, Wicklow, 12/'31;
II & III on do.	Killakee, Dublin, 4/'34.

**Milesia Kriegeriana* (Magn.) Arth.

II on *Lastrea aristata*:	Courtown, Wexford, 6/'35;
II on *L. Filix-mas* and *L. aristata*:	Powerscourt, Wicklow, 5/'34;
II on *L. aristata*:	Killakee, Dublin, 5/'34;
II on do.	Castleblayney, Monaghan, 6/'35.

**Aecidium pseudo-columnare* Kühn.

I on *Abies pectinata*:	The Ford, Wexford, 8/'33: Prof. J. Doyle;
I on do.	Powerscourt, Wicklow, 11/'31.

Ustilaginales.

Ustilago violacea Rob.

on *Stellaria uliginosa*:	Dingle, Dublin, 6/'33;
on *Lychnis alba*:	Baltray, Louth, 6/'33: Dr. R. L. Praeger;
on *Lychnis dioica*:	Castleblayney, Monaghan, 6/'35.

Ustilago longissima (Sow.) Tul.

on *Glyceria fluitans*:	Glasnevin, Dublin, 1/'33;
on *G. aquatica*:	Mullingar, Westmeath, 7/'35.

**Entyloma Helosciadii* Magn.

on *Sium erectum*:	Nenagh, Tipperary, 7/'33;
on do.	Clondalkin, Dublin, 10/'32.

Sphacelotheca Hydropiperis De Bary

on *Polygonum Persicaria*:	Farnanes, Cork, 8/'33;
on *P. Hydropiper*:	Powerscourt, Wicklow, 9/'32.

Urocystis Anemones Rab.

on *Ranunculus repens*:	Nenagh, Tipperary, 7/'33;
on do.	Birchfield, Kilkenny, 10/'33;
on do.	Athlone, Westmeath, 7/'34.

ASCOMYCETES.

Pyrenomycetes.

Plectomycetes.

Podosphaera Oxyacanthae de Bary

on *Crataegus Oxyacantha*:	Glengarriff, Cork, 6/'35;
on do.	Ring, Waterford, 10/'33;
on do.	Birchfield, Kilkenny, 10/'33;
on *Pyrus Malus*:	Tullamore, Offaly, 5/'34: Rev. Bro. T. Murphy;
on *C. monogyna*:	Celbridge, Kildare, 9/'34;
on *P. Malus*:	Sutton, Dublin, 11/'32;
on *C. Oxyacantha*:	Dowth, Meath, 7/'33;
on do.	Mullingar, Westmeath, 7/'35;
on do.	Belturbet, Cavan, 6/'35;
on do.	Drogheda, Louth, 7/'33;
on do.	Castleblayney, Monaghan, 6/'35.

Sphaerotheca Castagnei Lév.

on *Epilobium montanum*:	Cobh, Cork, 6/'35;
on *Senecio aquaticus*:	Dromineer, Tipperary, 7/'33;
on *Taraxacum vulgare*:	Birchfield, Kilkenny, 10/'33;
on *Epilobium hirsutum*:	Leixlip, Kildare, 7/'33;
on *Poterium Sanguisorba*:	Greenhills, Dublin, 10/'34.

Uncinula Aceris DC.

on *Acer Pseudo-platanus*:	Birchfield, Kilkenny, 10/'33;
on do.	Poulaphouca, Kildare, 8/'33;
on do.	Powerscourt, Wicklow, 9/'32;
on do.	Malahide, Dublin, 10/'32.

**Microsphaera Alni* Wint.

on *Alnus rotundifolia*:	Birchfield, Kilkenny, 10/'33;
on do.	Powerscourt, Wicklow, 10/'33.

Erysiphe graminis DC.

on *Dactylis glomerata*:	Kiltiernan, Dublin, 10/'32;
on *Bromus mollis*:	Boyne Valley, Louth, 7/'33.

Erysiphe Polygoni (DC.) Salmon

on *Ranunculus repens*:	Birchfield, Kilkenny, 10/'33.

Erysiphe Umbelliferarum de Bary
on *Heracleum Sphondylium* and *Angelica sylvestris*: Ring, Waterford, 10/'33;
on *Caucalis Anthriscus*: Scarriff, Clare, 7/'33;
on *Angelica sylvestris*: Portroe, Tipperary, 7/'33;
on *H. Sphondylium*: Birchfield, Kilkenny, 10/'33;
on do. Maynooth, Kildare, 7/'33;
on do. Powerscourt, Wicklow, 9/'32;
on do. Dowth, Meath, 7/'33.

Asterina Veronicae Cooke
on *Veronica officinalis*: Killakee, Dublin, 4/'33.

SPHAERIALES.

**Guignardia Cookeana* (Auersw.) Lindau
on *Quercus Robur*: Powerscourt, Wicklow, 3/'36: Prof. J. Doyle.

Rosellinia thelena Rab.
on *Picea exelsa*: Powerscourt, Wicklow, 10/'33.

Stigmatea Robertiani Fr.
on *Geranium Robertianum*: Killarney, Kerry, 6/'35;
on do. Kenmare, Kerry, 3/'34;
on do. Gougane Barra, Cork, 6/'35;
on do. Ring, Waterford, 10/'33;
on do. Croagh, Limerick, 12/'34;
on do. Burren, Clare, 7/'34;
on do. Nenagh, Tipperary, 7/'33;
on do. Courtown, Wexford, 6/'35;
on do. Recess, Galway, 7/'34;
on do. Golden Ball, Dublin, 1/'34;
on do. Cong, Mayo, 7/'34;
on do. Belturbet, Cavan, 6/'35;
on do. Boyne Valley, Louth, 7/'33.

Mycosphaerella Fragariae (Tul.) Lindau
on *Fragaria vesca*: Kenmare, Kerry, 3/'34;
on do. Newcastle West, Limerick, 2/'34: Mrs. H. Lloyd.

Mycosphaerella isariphora (Desm.) Lind.
on *Stellaria Holostea*: Ballyboden, Dublin, 4/'33;
on do. Castleblayney, Monaghan, 6/'35.

**Mycosphaerella Clymenia* Johans. et Magn.
on *Lonicera Periclymenum*: Powerscourt, Wicklow, 10/'33.

**Laestadia rhytismoides* Sacc.	
on *Dryas octopetala*:	Burren, Clare, 7/'34;
on do.	Gentian Island, Galway, 10/'32: Prof. T. Dinan.
**Laestadia Periclymeni* Pass.	
on *Lonicera Periclymenum*:	Blessington, Wicklow, 7/'35.
**Laestadia Polygonorum* Sacc.	
on *Polygonum Persicaria*:	Dingle, Dublin, 4/'33.
**Didymosphaeria crastophila* (Niessl.) Wint. var. *Brachypodii* Feltg.	
on *Brachypodium sylvaticum*:	Skerries, Dublin, 6/'35.
Venturia Rumicis Wint.	
on *Rumex obtusifolius*:	Kenmare, Kerry, 12/'34;
on do.	Cappoquin, Waterford, 6/'35;
on do.	Celbridge, Kildare, 6/'34;
on do.	Dunboyne, Meath, 6/'34.
**Venturia Myrtilli* Cooke	
on *Vaccinium Myrtillus*:	Glencullen, Dublin, 2/'36.
**Leptosphaeria culmorum* Auersw.	
on *Brachypodium sylvaticum*:	Clonee, Meath, 6/'35.
**Leptosphaeria Rusci* Sacc.	
on *Ruscus aculeatus*:	Howth, Dublin, 5/'35.
**Leptosphaeria modesta* Auersw.	
on *Scabiosa Succisa*:	Mullingar, Westmeath, 7/'35.
Leptosphaeria acuta Karst.	
on *Urtica dioica*:	Parknasilla, Kerry, 4/'34;
on do.	Glengarriff, Cork, 6/'35;
on do.	Courtown, Wexford, 6/'35;
on do.	Turraun, Offaly, 4/'33;
on do.	Leixlip, Kildare, 6/'35;
on do.	Blessington, Wicklow, 7/'35;
on do.	Lamb's Cross, Dublin, 4/'33;
on do.	Castleblayney, Monaghan, 6/'35.
**Pleospora infectoria* Fuck.	
on *Ammophila arenaria*:	Newcastle, Wicklow, 5/'35.
**Pleospora herbarum* Rab. fa. *Armeriae* Sacc.	
on *Armeria pubescens*:	Baltray, Louth, 10/'35.
Naumovia abundans Dobr.	
on *Prunella vulgaris*:	Kenmare, Kerry, 3/'34;
on do.	Powerscourt, Wicklow, 10/'31;
on do.	Raheny, Dublin, 10/'32.

**Anthostoma Plowrightii* Sacc.
on *Ulex europaeus*: Carrickmines, Dublin, 3/'35.

**Calospora platanoides* (Pers.) Niessl.
on *Acer Pseudo-platanus*: Kiltiernan, Dublin, 3/'36.

**Melogramma spiniferum* (Wallr.) De Not.
on *Fagus sylvatica*: Powerscourt, Wicklow, 5/'36.

Xylaria carpophila Fr.
on *Fagus sylvatica*: Killarney, Kerry, 6/'35;
on do. Cappoquin, Waterford, 6/'35;
on do. Celbridge, Kildare, 6/'35;
on do. Blessington, Wicklow, 7/'35;
on do. nr. Cavan, 7/'35.

Xylaria polymorpha Grev.
on decaying wood: Kilbride, Wicklow, 8/'32.

Dothideales.

Phyllachora graminis (Pers.) Fck.
on *Dactylis glomerata*: Kenmare, Kerry, 12/'34;
on do. Ring, Waterford, 10/'33;
on *Agropyron caninum*: Charleville, Offaly, 7/'34: J. P. Brunker;
on *Festuca ovina*: Leixlip, Kildare, 7/'33;
on *Dactylis glomerata*: Clonsilla, Dublin, 10/'32.

Dothidella Ulmi Wint.
on *Ulmus campestris*: Birchfield, Kilkenny, 10/'33;
on do. Borris, Carlow, 10/'33: Dr. M. O'Leary;
on do. Celbridge, Kildare, 9/'34;
on do. Powerscourt, Wicklow, 10/'33;
on do. Clondalkin, Dublin, 10/'32.

Rhopographus Pteridis (Sow.) Wint.
on *Pteris aquilina*: Raleagh, Kerry, 6/'35;
on do. Courtown, Wexford, 6/'35.

Hypocreales.

Hypomyces chrysospermus Tul.
on *Boletus* sp.: Kilmashogue, Dublin, 11/'33.

Nectria cinnabarina Fr.
on bark: Ashford, Wicklow, 10/'32;
on *Tilia vulgaris*: Milltown, Dublin, 2/'35.

**Nectria punicea* (Schmidt) Rabenh.
on *Ilex Aquifolium*: Stillorgan, Dublin, 4/'35.

Nectria galligena Bres.
on *Fraxinus excelsior*: Powerscourt, Wicklow, 4/'35.

Nectria sanguinea Fr.
on *Hedera Helix*: Glengarriff, Cork, 6/'35.

Epichloë typhina Tul.
on *Holcus lanatus*: Ashford, Wicklow, 6/'34;
on *H. mollis*: Howth, Dublin, 7/'33.

Hysteriales.

Gloniopsis curvata Sacc.
on *Rhododendron* sp.: Powerscourt, Wicklow, 5/'36.

Discomycetes.

Taphridium Umbelliferarum (Rostr.) Lag. et Juel
on *Heracleum Sphondylium*: Killarney, Kerry, 6/'35;
on do. Cappoquin, Waterford, 6/'35;
on do. Courtown, Wexford, 6/'35;
on do. Celbridge, Kildare, 6/'35;
on do. Enniskerry, Wicklow, 5/'33;
on do. Dunboyne, Meath, 6/'34.

Taphrina Pruni (Fuck.) Tul.
on *Prunus spinosa*: Courtown, Wexford, 6/'35.

Taphrina deformans (Fuck.) Tul.
on *Prunus Amygdalus*: Mallow, Cork, 6/'35.

**Taphrina marginata* Lamb. et Fautr.
on *Crataegus monogyna*: Parknasilla, Kerry, 6/'35;
on *C. Oxyacantha*: Glengarriff, Cork, 6/'35;
on *C. monogyna*: Cappoquin, Waterford, 6/'35;
on *C. Oxyacantha*: Nenagh, Tipperary, 7/'33;
on do. Courtown, Wexford, 6/'35;
on do. Celbridge, Kildare, 6/'35;
on do. Blessington, Wicklow, 7/'35;
on do. Knockmaroon, Dublin, 6/'35;
on do. Belturbet, Cavan, 6/'35.

Taphrina Tosquineti (West.) Magn.
on *Alnus rotundifolia*: Bride's Glen, Dublin, 7/'35;
on do. Mullingar, Westmeath, 7/'35.

**Exoascus Alni-incanae* (Kühn) P. Magn.
on *Alnus rotundifolia*: Farnanes, Cork, 8/'34;
on do. Mullingar, Westmeath, 7/'35.

**Exoascus Crataegi* Sacc.
on *Crataegus Oxyacantha*: Glengarriff, Cork, 6/'35;
on do. Celbridge, Kildare, 6/'35;
on *C. monogyna*: Castleblayney, Monaghan, 6/'35.

**Endomyces decipiens* Reess
on *Armillaria mellea*: Kilmashogue, Dublin, 11/'33.

Rhytisma acerinum Fr.
on *Acer Pseudo-platanus*: Derrynane, Kerry, 8/'33: Dr. M. O'Leary;
on do. Scarriff, Clare, 7/'33;
on do. Portroe, Tipperary, 7/'33;
on do. Birchfield, Kilkenny, 10/'33;
on do. nr. Cavan, 7/'35.

Rhytisma salicinum (Pers.) Fr.
on *Salix cinerea*: Parknasilla, Kerry, 6/'35;
on *S. triandra*: Knocksedan, Dublin, 11/'32.

**Dermatea umbrina* Cooke et Massee
on *Ulex europaeus*: Newcastle, Wicklow, 5/'35.

Bulgaria inquinans (Pers.) Fr.
on *Quercus Robur*: Powerscourt, Wicklow, 9/'32.

Pseudopeziza Trifolii Fckl.
on *Trifolium repens*: Courtown, Wexford, 6/'35.

Pseudopeziza Medicaginis (Lib.) Sacc.
on *Medicago lupulina*: Headford, Galway, 7/'34;
on do. Raheny, Dublin, 7/'33.

**Pseudopeziza Cerastiorum* (Wallr.) Fuck.
on *Cerastium vulgatum*: Kenmare, Kerry, 12/'34;
on do. Ticknock, Dublin, 7/'35.

**Fabraea Rousseauana* Sacc.
on *Caltha palustris*: Knocksedan, Dublin, 11/'32.

Fabraea Ranunculi Karst.
on *Ranunculus repens*: Birchfield, Kilkenny, 10/'33.

Mollisia cinerea (Batsch) Karst.
on *Calluna vulgaris*: Raleagh, Kerry, 6/'35;
on do. Keamaneigh, Cork, 6/'35.

Stamnaria Equiseti (Hoffm.) Sacc.
on *Equisetum Moorei*: Arklow, Wicklow, 6/'35: M. J. Gorman, A.R.C.Sc.I.

Helotium Scutula Karst.
on *Cnicus* sp.: Courtown, Wexford, 6/'35.

Dasyscypha clandestina Fuck.
on *Lonicera Periclymenum*: The Dargle, Wicklow, 4/'35.

Otidea aurantia Mass.
on soil: Kilmashogue, Dublin, 11/'33: A. W. Stelfox, M.R.I.A.

**Micropodia pteridina* (Karst.) Boud.
on *Pteris aquilina*: Killarney, Kerry, 6/'35;
on do. Courtown, Wexford, 6/'35;
on do. Howth, Dublin, 7/'35.

Morchella esculenta L.
on soil: Glencullen, Wicklow, 3/'32: A. W. Stelfox, M.R.I.A.

Hemiasceae.

Protomyces macrosporus Ung.
on *Aegopodium Podagraria*: Killarney, Kerry, 6/'35;
on do. Ring, Waterford, 10/'33;
on do. Birchfield, Kilkenny, 10/'33;
on do. Celbridge, Kildare, 6/'34;
on *Heracleum Sphondylium*: Lamb's Cross, Dublin, 4/'33;
on *A. Podagraria*: Mullingar, Westmeath, 7/'35;
on do. Belturbet, Cavan, 6/'35;
on do. Castleblayney, Monaghan, 6/'35.

PHYCOMYCETES.

Synchytrium Taraxaci de Bary et Wor.
on *Taraxacum vulgare*: Cappoquin, Waterford, 6/'35;
on do. Scarriff, Clare, 7/'33;
on do. Blessington, Wicklow, 7/'35;
on do. Castleblayney, Monaghan, 6/'35.

**Synchytrium anomalum* Schröt.
on *Ranunculus Ficaria*: The Dargle, Wicklow, 4/'35.

Cladochytrium Menyanthis de Bary
on *Menyanthes trifoliata*: Mullingar, Westmeath, 7/'35.

**Physoderma vagans* Schröt.

on *Sium erectum*:	Clondalkin, Dublin, 10/'32;
on do.	Mullingar, Westmeath, 7/'35;
on do.	Belturbet, Cavan, 6/'35.

Cystopus candidus (Pers.) Lév.

on *Cochlearia officinalis*:	Kenmare, Kerry, 12/'34;
on *Capsella Bursa-pastoris*:	Cappoquin, Waterford, 6/'35;
on do.	Cashel, Tipperary, 6/'35;
on do.	Dromineer, Tipperary, 4/'33;
on *Sisymbrium officinale*:	Malahide, Dublin, 10/'32;
on *C. Bursa-pastoris*:	Belturbet, Cavan, 6/'35.

Cystopus Lepigoni de Bary

on *Spergularia rupestris*:	Dun Laoghaire, Dublin, 10/'32.

Cystopus Tragopogonis (Pers.) Schroet.

on *Cnicus palustris*:	Parknasilla, Kerry, 6/'35.

Plasmopara nivea Schroet.

on *Angelica sylvestris*:	Killarney, Kerry, 6/'35;
on do.	Farnanes, Cork, 8/'33;
on *Aegopodium Podagraria*:	nr. Waterford, 6/'35;
on *Angelica sylvestris*:	Belturbet, Cavan, 6/'35;
on do.	Boyne Valley, Louth, 7/'33;
on do.	Castleblayney, Monaghan, 6/'35.

Plasmopara densa Schroet.

on *Rhinanthus minor*:	Killarney, Kerry, 6/'35;
on *Bartsia Odontites*:	Farnanes, Cork, 7/'33;
on do.	Cappoquin, Waterford, 6/'35;
on do.	Dromineer, Tipperary, 7/'33;
on do.	Malahide, Dublin, 7/'35;
on do.	Dowth, Meath, 7/'33;
on do.	Mullingar, Westmeath, 7/'35.

Bremia Lactucae Regel.

on *Senecio vulgaris* and *Sonchus oleraceus*:	Farnanes, Cork, 8/'33;
on do. do.	Clashmore, Waterford, 5/'34;
on *Senecio aquaticus*:	Nenagh, Tipperary, 7/'33;
on *Senecio vulgaris*:	Birchfield, Kilkenny, 10/'33;
on *Sonchus oleraceus*:	Courtown, Wexford, 6/'35;
on *Senecio vulgaris*:	Boyne Valley, Louth, 7/'33;
on *Centaurea nigra*:	Castleblayney, Monaghan, 6/'35.

Peronospora calotheca de Bary	
on *Galium Aparine*:	Farnanes, Cork, 6/'35;
on do.	Ring, Waterford, 10/'33;
on do.	Scarriff, Clare, 7/'33;
on do.	Nenagh, Tipperary, 7/'33;
on do.	Courtown, Wexford, 6/'35;
on do.	Celbridge, Kildare, 6/'35;
on *Asperula odorata*:	The Dargle, Wicklow, 4/'35;
on *G. Aparine*:	Dowth, Meath, 7/'33;
on do.	Mullingar, Westmeath, 7/'35;
on do.	Belturbet, Cavan, 6/'35;
on do.	Boyne Valley, Louth, 7/'33;
on do.	Castleblayney, Monaghan, 6/'35.
**Peronospora Alsinearum* Casp.	
on *Cerastium vulgatum*:	Mallow, Cork, 6/'35;
on do.	Scarriff, Clare, 7/'33;
on do.	Courtown, Wexford, 6/'35;
on *Stellaria media*:	Blessington, Wicklow, 7/'35;
on do.	Howth, Dublin, 9/'32;
on *C. vulgatum*:	Mullingar, Westmeath, 7/'35;
on do.	Castleblayney, Monaghan, 6/'35.
**Peronospora Viciae* Casp.	
on *Vicia sepium*:	Courtown, Wexford, 6/'35;
on do.	Mullingar, Westmeath, 7/'35.
Peronospora Trifoliorum de Bary	
on *Trifolium pratense*:	Courtown, Wexford, 6/'35.
Peronospora affinis Rossm.	
on *Fumaria officinalis*:	Farnanes, Cork, 8/'33;
on do.	Birchfield, Kilkenny, 10/'33;
on do.	Boyne Valley, Meath, 7/'33.
Peronospora effusa Rab.	
on *Chenopodium album*:	Farnanes, Cork, 8/'33;
on do.	Scarriff, Clare, 7/'33;
on do.	Leixlip, Kildare, 6/'33.
Peronospora grisea Unger.	
on *Veronica Beccabunga*:	Glengarriff, Cork, 6/'35;
on do.	Poulaphouca, Kildare, 8/'33;
on do.	Mullingar, Westmeath, 7/'35;
on do.	Belturbet, Cavan, 6/'35.

**Peronospora Linariae* Fuck.

on *Linaria Cymbalaria*:	Killarney, Kerry, 6/'35;
on do.	Cappoquin, Waterford, 6/'35;
on do.	Rathfarnham, Dublin, 7/'35;
on do.	Mullingar, Westmeath, 7/'35;
on do.	Belturbet, Cavan, 6/'35.

Peronospora Ficariae Tul.

on *Ranunculus Ficaria*:	Tramore, Waterford, 3/'34;
on do.	Adare, Limerick, 3/'34.

**Peronospora conglomerata* Fuck.

on *Geranium molle*:	Clonsilla, Dublin, 3/'36.

Peronospora parasitica Tul.

on *Capsella Bursa-pastoris*:	Kenmare, Kerry, 3/'34.

Peronospora sordida Berk.

on *Scrophularia nodosa*:	Killarney, Kerry, 6/'35;
on do.	Courtown, Wexford, 6/'35;
on do.	Carton, Kildare, 5/'35.

FUNGI IMPERFECTI.

Sphaeropsidales.

**Phyllosticta cornicola* Raben.

on *Cornus sanguinea*:	Donabate, Dublin, 11/'35.

Phyllosticta hederaecola Dur. et Mont.

on *Hedera Helix*:	Killarney, Kerry, 6/'35;
on do.	Kenmare, Kerry, 3/'34;
on do.	Keamaneigh, Cork, 6/'35;
on do.	Farnanes, Cork, 8/'33;
on do.	Ring, Waterford, 10/'33;
on do.	Dromineer, Tipperary, 4/'33;
on do.	Adare, Limerick, 3/'34;
on do.	Scarriff, Clare, 7/'33;
on do.	Birchfield, Kilkenny, 10/'33;
on do.	Courtown, Wexford, 6/'35;
on do.	Corrib, Galway, 7/'34;
on do.	Turraun, Offaly, 4/'33;
on do.	Leixlip, Kildare, 7/'33;
on do.	Dowth, Meath, 7/'33;
on do.	Cong, Mayo, 7/'34;
on do.	Belturbet, Cavan, 6/'35;
on do.	Boyne Valley, Louth, 7/'33;
on do.	Castleblayney, Monaghan, 6/'35.

**Phyllosticta Glechomae* Sacc.
on *Nepeta hederacea*: Scarriff, Clare, 7/'33.

**Phyllosticta Tormentillae* Sacc.
on *Potentilla erecta*: Roundwood, Wicklow, 2/'33.

**Phyllosticta Ulmariae* Thüm.
on *Spiraea Ulmaria*: Knocksedan, Dublin, 11/'32.

**Phyllosticta Vincae-majoris* All.
on *Vinca major*: Stillorgan, Dublin, 11/'32.

**Phoma vulgaris* Sacc.
on *Clematis Vitalba*: Dalkey, Dublin, 4/'36.

**Phoma Araucariae* Trav.
on *Araucaria imbricata*: Powerscourt, Wicklow, 3/'36.

**Phoma Crataegi* Sacc.
on *Crataegus monogyna*: Carrickmines, Dublin, 3/'35.

**Phoma Zopfiana* All.
on *Ononis repens*: Howth, Dublin, 10/'32.

**Phoma Rhododendri* Cooke
on *Rhododendron* sp.: Powerscourt, Wicklow, 5/'36.

**Phoma exigua* Desm.
on *Sambucus nigra*: Dunboyne, Meath, 3/'36.

**Asteroma Aceris* Rob. et Desm.
on *Acer Pseudo-platanus*: Harold's Cross, Dublin, 12/'32.

***Cicinnobolus Plantaginis* Oud.
on *Plantago maritima*: Sutton, Dublin, 7/'33.

Cicinnobolus Ulicis Adams
on *Ulex europaeus*: Howth, Dublin, 9/'32.

**Phomopsis stictica* Trav.
on *Buxus sempervirens*: Enniskerry, Wicklow, 4/'36.

**Phomopsis scobina* v. Höhn.
on *Fraxinus excelsior*: Greenhills, Dublin, 3/'36.

**Phomopsis depressa* Trav.
on *Syringa vulgaris*: Milltown, Dublin, 4/'36.

**Phomopsis oblonga* Trav.
on *Ulmus montana*: Milltown, Dublin, 4/'36.

**Dothiorella fraxinea* Sacc. et Roum.
on *Fraxinus excelsior*: Dunboyne, Meath, 3/'36.

**Cytospora ambiens* Sacc.
on *Fagus sylvatica*: Kilmashogue, Dublin, 4/'36.

**Cytospora Oxyacanthae* Rab.
on *Crataegus Oxyacantha*: Ticknock, Dublin, 4/'36.

**Cytospora microstoma* Sacc.
on *Prunus Laurocerasus*: Milltown, Dublin, 4/'36.

**Cytospora Rosarum* Grev.
on *Rosa canina*: Kiltiernan, Dublin, 3/'36.

**Ascochyta microspora* Trail
on *Petasites fragrans*: Stillorgan, Dublin, 4/'35.

**Ascochyta Chenopodii* Rostr.
on *Chenopodium album*: Corrib, Galway, 7/'34.

**Ascochyta Heraclei* Bres.
on *Heracleum Sphondylium*: Glenasmole, Dublin, 11/'32.

**Ascochyta Lycopersici* Brun.
on *Lycopersicum esculentum*: Ranelagh, Dublin, 2/'36.

**Ascochyta Psammae* Oud.
on *Ammophila arenaria*: The Murrough, Wicklow, 5/'35.

**Ascochytula Symphoricarpi* Died.
on *Symphoricarpus racemosus*: Kilmashogue, Dublin, 4/'36.

Darluca Filum Cast.
on *Puccinia Menthae*: Ring, Waterford, 10/'33;
on do. Birchfield, Kilkenny, 10/'33;
on *Uromyces Fabae*: Maynooth, Kildare, 7/'33;
on *Holcus lanatus*: Roundwood, Wicklow, 2/'33;
on *Arrhenatherum elatius*: Killiney, Dublin, 10/'32.

**Stagonospora Calystegiae* Grove
on *Calystegia Soldanella*: Ballyteigue, Wexford, 7/'35: Prof. J. Doyle.

**Septoria Unedinis* Rob. et Desm.
on *Arbutus unedo*: Killarney, Kerry, 6/'35;
on do. Carrickmines, Dublin, 5/'33.

**Septoria Cerastii* Rob. et Desm.
on *Cerastium tetrandrum*: Killegar, Wicklow, 10/'35.

**Septoria Chelidonii* Desm.
on *Chelidonium majus*: Newgrange, Meath, 7/'35.

Septoria Epilobii West.
on *Epilobium hirsutum*: Carrickmines, Dublin, 12/'32.

**Septoria Brissaceana* Sacc. et Let.
on *Lythrum Salicaria*: Ballyhaise, Cavan, 7/'34: D. Hurley.

**Septoria Menyanthis* Desm.
on *Menyanthes trifoliata*: Maynooth, Kildare, 7/'33.

Septoria Polygonorum Desm.
on *Polygonum Persicaria*: Farnanes, Cork, 8/'33;
on do. Scarriff, Clare, 7/'33.

**Septoria Tormentillae* Rob. et Desm.
on *Potentilla reptans*: Listowel, Kerry, 6/'35: R. R. Pierse, M.R.C.V.S.;
on *P. erecta*: Killakee, Dublin, 4/'34.

**Septoria Prunellae* Ell. et Harkn.
on *Prunella vulgaris*: Devil's Glen, Wicklow, 6/34.

**Septoria Ficariae* Desm.
on *Ranunculus Ficaria*: Powerscourt, Wicklow, 5/'34.
on *R. flammula*: Dingle, Dublin, 10/'32.

***Septoria Rubiae* (Pat.) Bubak et Ranoj.
on *Rubia peregrina*: Killarney, Kerry, 6/'35.

Septoria Rubi West.
on *Rubus saxatilis*: Burren, Clare, 7/'34;
on *R. fruticosus*: Courtown, Wexford, 6/'35;
on do. Recess, Galway, 7/'34;
on do. Celbridge, Kildare, 6/'35.

Septoria scabiosaecola Desm.
on *Scabiosa Succisa*: Parknasilla, Kerry, 6/'35;
on do. Gougane Barra, Cork, 6/'35;
on do. Burren, Clare, 7/'34;
on do. Recess, Galway, 7/'34;
on do. Mullingar, Westmeath, 7/'35.

***Septoria Saxifragae* Pass.
on *Saxifraga spathularis*: Carrickmines, Dublin, 11/'34.

**Septoria Senecionis-silvatici* Syd.
on *Senecio aquaticus*: Dingle, Dublin, 10/'32.

**Septoria Stachydis* Rob. et Desm.
on *Stachys sylvatica*: Birchfield, Kilkenny, 10/'33;
on do. Leopardstown, Dublin, 11/'35.

**Septoria Stellariae* Rob. et Desm.
on *Stellaria media*: Kenmare, Kerry, 3/'34;
on do. Maynooth, Kildare, 7/'33;
on do. Howth, Dublin, 7/'33;
on do. Dunboyne, Meath, 6/'34.

Septoria Veronicae Desm.
on *Veronica* sp.: Kenmare, Kerry, 12/'34;
on do. nr. Waterford, 6/'35.

**Septoria minuta* Schröt.
on *Luzula sylvatica*: Courtown, Wexford, 6/'35.

Phleospora Aegopodii Desm.
on *Aegopodium Podagraria*: Killarney, Kerry, 6/'35;
on do. Cappoquin, Waterford, 6/'35;
on do. Celbridge, Kildare, 9/'34;
on do. Greystones, Wicklow, 9/'34;
on do. Rathgar, Dublin, 7/'33;
on do. Mullingar, Westmeath, 7/'35;
on do. Belturbet, Cavan, 6/'35;
on do. Mellifont, Louth, 6/'35.

***Rhabdospora lentiformis* Sacc.
on *Fraxinus excelsior*: Dunboyne, Meath, 3/'36.

**Coniothyrium olivaceum* Bon.
on *Fraxinus excelsior*: Dunboyne, Meath, 3/'36.

**Microdiplodia Narthecii* Allescher
on *Narthecium ossifragum*: Recess, Galway, 7/'34;
on do. Howth, Dublin, 7/'33;
on do. Mullingar, Westmeath, 7/'35.

**Diplodia Pinastri* Grove
on *Pinus sylvestris*: Kenmare, Kerry, 12/'34.

**Hendersonia Fiedleri* West.
on *Cornus sanguinea*: Donabate, Dublin, 11/'35.

**Hendersonia Grossulariae* Oud.
on *Ribes Grossularia*: Ranelagh, Dublin, 1/'35.

**Leptothyrium Scorodoniae* Sacc.
on *Teucrium Scorodonia*: Kilmashogue, Dublin, 4/'36.

**Sporonema strobilinum* Desm.
on *Abies pectinata*: Killakee, Dublin, 5/'36.

**Sporonema strobilinum* Desm. var. *microsporum* Allesch.
on *Larix europaea*: Powerscourt, Wicklow, 3/'36: Prof. J. Doyle.

**Psilospora Quercus* Rab.
on *Quercus Robur*: The Dargle, Wicklow, 4/'35.

Melanconiales.

**Marssonia Betulae* Sacc.	
on *Betula alba*:	Howth, Dublin, 10/'35: Dr. M. O'Leary.
Marssonia Potentillae Sacc.	
on *Potentilla reptans*:	Birchfield, Kilkenny, 10/'33;
on do.	Celbridge, Kildare, 9/'34;
on do.	Kelly's Glen, Dublin, 10/'32;
on do.	Mullingar, Westmeath, 7/'35.
Pestalozzia funerea Desm.	
on *Cupressus macrocarpa*:	nr. Waterford, 6/'35.

Hyphomycetales.

**Oospora candidula* Sacc.	
on *Polyporus betulinus*:	Killarney, Kerry, 6/'35.
Cylindrium griseum Bonord	
on *Quercus Robur*:	Powerscourt, Wicklow, 10/'33.
**Oidium erysiphoides* Fr.	
on *Bellis perennis*:	Poulaphouca, Kildare, 8/'33.
Oidium alphitoides Griff. et Maubl.	
on *Quercus Robur*:	nr. Waterford, 6/'35;
on do.	Portroe, Tipperary, 7/33;
on do.	Courtown, Wexford, 6/'35;
on do.	Leixlip, Kildare, 7/'33;
on do.	Kilbride, Wicklow, 8/'32;
on do.	Ballyboden, Dublin, 12/'32.
**Oidium Passerinii* Bertol.	
on *Prunus Laurocerasus*:	Castlelyons, Cork, 7/'33: Miss E. F. Bond.
**Oidium Euonymi-japonicae* Sacc.	
on *Euonymus japonicus*:	Galway, 11/'32; Prof. T. Dinan;
on do.	Foxrock, Dublin, 9/'32: Prof. J. Doyle.
**Sporotrichum geochroum* Desm.	
on *Fraxinus excelsior*:	Greenhills, Dublin, 3/'36.
**Ovularia destructiva* (Phill. et Plowr.) Rab.	
on *Myrica Gale*:	Killarney, Kerry, 6/'35;
on do.	Recess, Galway, 7/'34;
on do.	Mullingar, Westmeath, 7/'35.

Ovularia obliqua (Cooke) Oud.	
on *Rumex obtusifolius*:	Kenmare, Kerry, 3/'34;
on do.	Gougane Barra, Cork, 6/'35;
on do.	Farnanes, Cork, 8/'33;
on do.	Tramore, Waterford, 3/'34;
on do.	Cashel, Tipperary, 6/'35;
on do.	Adare, Limerick, 3/'34;
on do.	Scarriff, Clare, 7/'33;
on do.	Dromineer, Tipperary, 7/'33;
on do.	Birchfield, Kilkenny, 10/'33;
on do.	Courtown, Wexford, 6/'35;
on do.	Corrib, Galway, 7/'34;
on do.	Turraun, Offaly, 4/'33;
on do.	Maynooth, Kildare, 7/'33;
on do.	Dowth, Meath, 7/'33;
on do.	Mullingar, Westmeath, 7/'35;
on *R. crispus*:	Cong, Mayo, 7/'34;
on *R. obtusifolius*:	Belturbet, Cavan, 6/'35;
on do.	Castleblayney, Monaghan, 6/'35.
Ovularia sphaeroidea Sacc.	
on *Lotus uliginosus*:	Killarney, Kerry, 6/'35;
on do.	Farnanes, Cork, 8/'33;
on do.	Ring, Waterford, 10/'33;
on do.	Scarriff, Clare, 7/'33;
on do.	Avondale, Wicklow, 10/'32;
on do.	Dowth, Meath, 7/'33;
on do.	nr. Cavan, 7/'35;
on do.	Castleblayney, Monaghan, 6/'35.
Ovularia deusta Sacc.	
on *Lathyrus pratensis*:	Howth, Dublin, 7/'33.
**Ovularia epilobiana* Sacc. et Fautr.	
on *Epilobium hirsutum*:	Leixlip, Kildare, 7/'33.
Ovularia primulana Karst.	
on *Primula vulgaris*:	Kenmare, Kerry, 3/'34;
on do.	Farnanes, Cork, 8/'33;
on do.	Burren, Clare, 7/'34;
on do.	Portroe, Tipperary, 7/'33;
on do.	Courtown, Wexford, 6/'35.
**Ovularia Veronicae* (Fuck.) Sacc.	
on *Veronica Chamaedrys*:	Courtown, Wexford, 6/'35;
on do.	Corrib, Galway, 7/'34;
on do.	Tibradden, Dublin, 2/'36;
on do.	Dunboyne, Meath, 6/'34;
on do.	Castleblayney, Monaghan, 6/'35.

**Ovularia Inulae* Sacc.
on *Pulicaria dysenterica*: Birchfield, Kilkenny, 10/'33.

**Verticillium Buxi* Auersw. et Flsch.
on *Buxus sempervirens*: Stillorgan, Dublin, 10/'35.

**Didymaria didyma* Schröt.
on *Ranunculus repens*: nr. Waterford, 6/'35;
on do. Cashel, Tipperary, 6/'35;
on do. Nenagh, Tipperary, 7/'33;
on do. Headford, Galway, 7/'34;
on do. Recess, Galway, 7/'34;
on do. Poulaphouca, Kildare, 8/'33;
on do. Clonsilla, Dublin, 10/'32;
on do. Dowth, Meath, 7/'33;
on do. Mullingar, Westmeath, 7/'35;
on do. Cong, Mayo, 7/'34;
on do. Belturbet, Cavan, 6/'35;
on do. Boyne Valley, Louth, 7/'33;
on do. Castleblayney, Monaghan, 6/'35.

**Ramularia Scolopendrii* Fautr.
on *Phyllitis Scolopendrium*: Glengarriff, Cork, 6/'35;
on do. Burren, Clare, 7/'34;
on do. Courtown, Wexford, 6/'35;
on do. Celbridge, Kildare, 6/'35;
on do. Powerscourt, Wicklow, 4/'34;
on do. Dingle, Dublin, 5/'34;
on do. Dunboyne, Meath, 6/'34;
on do. Castleblayney, Monaghan, 6/'35.

**Ramularia Alismatis* Fautr.
on *Alisma Plantago-aquatica*: Leixlip, Kildare, 7/'33;
on do. Mullingar, Westmeath, 7/'35.

Ramularia Urticae Ces.
on *Urtica dioica*: Kenmare, Kerry, 12/'34;
on *U. urens*: nr. Waterford, 6/'35;
on *U. dioica*: Birchfield, Kilkenny, 10/'33;
on do. Courtown, Wexford, 6/'35;
on do. Carton, Kildare, 5/'35;
on do. Knockmaroon, Dublin, 10/'32;
on do. Cong, Mayo, 7/'34;
on do. Castleblayney, Monaghan, 6/'35.

**Ramularia Parietariae* Pass.
on *Parietaria ramiflora*: Blarney, Cork, 6/'35;
on do. Cashel, Tipperary, 6/'35;
on do. Mellifont, Louth, 6/'35.

**Ramularia pratensis* Sacc.	
on *Rumex Acetosa*:	Gougane Barra, Cork, 6/'35;
on do.	Farnanes, Cork, 8/'34;
on do.	Tramore, Waterford, 3/'34;
on do.	Courtown, Wexford, 6/'35;
on do.	Carrickmines, Dublin, 10/'32;
on do.	Castleblayney, Monaghan, 6/'35.
**Ramularia Calthae* Lindr.	
on *Caltha palustris*:	Nenagh, Tipperary, 7/'33;
on do.	Corrib, Galway, 7/'34;
on do.	Carton, Kildare, 5/'35;
on do.	Knocksedan, Dublin, 11/'32;
on do.	Mullingar, Westmeath, 7/'35.
**Ramularia Ranunculi* Peck.	
on *Ranunculus Ficaria*:	Leixlip, Kildare, 3/'36.
**Ramularia Barbareae* Peck.	
on *Barbarea vulgaris*:	Greenhills, Dublin, 3/'36.
**Ramularia Saxifragae* Syd.	
on *Saxifraga spathularis*:	Kenmare, Kerry, 12/'34;
on do.	Carrickmines, Dublin, 11/'34.
**Ramularia Ulmariae* Cooke	
on *Spiraea Ulmaria*:	Birchfield, Kilkenny, 10/'33;
on do.	Knocksedan, Dublin, 11/'32.
**Ramularia Winteri* Thüm.	
on *Ononis repens*:	Maynooth, Kildare, 7/'33;
on do.	Malahide, Dublin, 10/'32.
**Ramularia Geranii* Fuck.	
on *Geranium pyrenaicum*:	Killakee, Dublin, 11/'34.
Ramularia lactea Sacc.	
on *Viola Riviniana*:	Killarney, Kerry, 6/'35;
on do.	Farran, Cork, 6/'35;
on do.	nr. Waterford, 6/'35;
on *V. sylvestris*:	Courtown, Wexford, 6/'35;
on *V. Riviniana*:	Celbridge, Kildare, 6/'35;
on *V. odorata*:	Knocksedan, Dublin, 11/'32;
on *V. sylvestris*:	Belturbet, Cavan, 6/'35;
on do.	Castleblayney, Monaghan, 6/'35.
Ramularia Epilobii Allesch.	
on *Epilobium hirsutum*:	Ring, Waterford, 10/'33.

**Ramularia punctiformis* v. Höhn.
on *Epilobium palustre*: Howth, Dublin, 7/'33.

**Ramularia Anthrisci* v. Höhn.
on *Anthriscus sylvestris*: Ballyduff, Waterford, 6/'35;
on do. Courtown, Wexford, 6/'35;
on do. Castleblayney, Monaghan, 6/'35.

Ramularia Heraclei Sacc.
on *Heracleum Sphondylium*: Courtown, Wexford, 6/'35;
on do. Avondale, Wicklow, 10/'32.

Ramularia Primulae Thuem.
on *Primula vulgaris*: Killarney, Kerry, 6/'35;
on do. Scarriff, Clare, 7/'33;
on do. Dromineer, Tipperary, 7/'33;
on do. Courtown, Wexford, 6/'35;
on do. Corrib, Galway, 7/'34;
on do. nr. Cavan, 7/'35.

Ramularia Ajugae Sacc.
on *Ajuga reptans*: Poulaphouca, Kildare, 8/'33.

Ramularia calcea Ces.
on *Nepeta hederacea*: Tramore, Waterford, 3/'34;
on do. Scarriff, Clare, 7/'33;
on do. Portroe, Tipperary, 7/'33;
on do. Courtown, Wexford, 6/'35;
on do. Birchfield, Kilkenny, 10/'33.

Ramularia variabilis Fuck.
on *Digitalis purpurea*: Parknasilla, Kerry, 4/'34;
on do. Keamaneigh, Cork, 6/'35;
on do. Farnanes, Cork, 6/'35;
on do. Courtown, Wexford, 6/'35;
on do. Stepaside, Dublin, 1/'34;
on do. Belturbet, Cavan, 6/'35;
on do. Castleblayney, Monaghan, 6/'35.

Ramularia Scrophulariae Fautr. et Roum.
on *Scrophularia aquatica*: Glengarriff, Cork, 6/'35;
on *S. nodosa*: Farnanes, Cork, 8/'33;
on *S. aquatica*: Nenagh, Tipperary, 7/'33;
on *S. nodosa*: Birchfield, Kilkenny, 10/'33;
on do. Kelly's Glen, Dublin, 10/'32.

**Ramularia obducens* Thüm.
on *Pedicularis palustris*: Dingle, Dublin, 10/'32.

Ramularia sambucina Sacc.
on *Sambucus nigra*: Carton, Kildare, 5/'35;
on do. Kiltiernan, Dublin, 10/'32;
on do. Mullingar, Westmeath, 7/'35;
on do. Castleblayney, Monaghan, 6/'35.

Ramularia Valerianae Sacc.
on *Valeriana sambucifolia*: Farnanes, Cork, 8/'33;
on *V. officinalis*: Maynooth, Kildare, 7/'33.

**Ramularia Centranthi* Brun.
on *Kentranthus ruber*: Killiney, Dublin, 10/'32.

**Ramularia Succisae* Sacc.
on *Scabiosa arvensis*: Malahide, Dublin, 10/'32.

**Ramularia purpurascens* Wint.
on *Petasites fragrans*: Killarney, Kerry, 6/'35;
on do. nr. Waterford, 6/'35;
on do. The Dargle, Wicklow, 4/'35;
on do. Dalkey, Dublin, 10/'32;
on *P. ovatus*: Belturbet, Cavan, 6/'35.

**Ramularia macrospora* Fres. var. *Senecionis* Sacc.
on *Senecio erucifolius*: Celbridge, Kildare, 9/'34.

**Ramularia Centaureae* Lind.
on *Centaurea nigra*: Celbridge, Kildare, 9/'34.

Ramularia Lapsanae (Desm.) Sacc.
on *Lapsana communis*: Killarney, Kerry, 6/'35;
on do. Farnanes, Cork, 8/'33;
on do. Ring, Waterford, 10/'33;
on do. Scarriff, Clare, 7/'33;
on do. Birchfield, Kilkenny, 10/'33;
on do. Courtown, Wexford, 6/'35;
on do. Poulaphouca, Kildare, 8/'33;
on do. Whitechurch, Dublin, 10/'32;
on do. Dowth, Meath, 7/'33;
on do. nr. Cavan, 7/'35;
on do. Castleblayney, Monaghan, 6/'35.

Ramularia Hypochaeridis Magn.
on *Hypochaeris radicata*: Gougane Barra, Cork, 6/'35;
on do. Farnanes, Cork, 8/'33;
on do. Howth, Dublin, 7/'35;
on do. Castleblayney, Monaghan, 6/'35.

Ramularia Taraxaci Karst.

on *Taraxacum vulgare*:	Cappoquin, Waterford, 6/'35;
on do.	Birchfield, Kilkenny, 10/'33;
on do.	Corrib, Galway, 7/'34;
on do.	Killiney, Dublin, 10/'32;
on do.	Mullingar, Westmeath, 7/'35;
on do.	Belturbet, Cavan, 6/'35.

**Torula convoluta* Harz.

on *Arbutus Unedo*:	Killarney, Kerry, 6/'35.

**Hormiscium pinophilum* (Nees) Lindau

on *Abies pectinata*:	Powerscourt, Wicklow, 5/'34.

**Hormiscium laxum* Wallr.

on *Urtica dioica*:	Killarney, Kerry, 6/'35;
on do.	Glengarriff, Cork, 6/'35;
on *U. urens*:	nr. Waterford, 6/'35;
on *U. dioica*:	Courtown, Wexford, 6/'35;
on do.	Celbridge, Kildare, 6/'35;
on do.	Ticknock, Dublin, 7/'35;
on do.	Castleblayney, Monaghan, 6/'35.

Fusicladium depressum Sacc.

on *Angelica sylvestris*:	Ring, Waterford, 10/'33;
on do.	Mullingar, Westmeath, 7/'35.

Cladosporium herbarum Link

on *Chenopodium album*:	Scarriff, Clare, 7/'33;

**Cladosporium graminum* Cda.

on *Phalaris arundinacea*:	Nenagh, Tipperary, 7/'33;
on *Poa pratensis*:	Birchfield, Kilkenny, 10/'33;
on *Carex pendula*:	Powerscourt, Wicklow, 2/'36: Prof. J. Doyle.

**Cladosporium fasciculatum* Cda.

on *Sparganium ramosum*:	Nenagh, Tipperary, 7/'33;
on *Scirpus lacustris*:	Maynooth, Kildare, 7/'33.

**Cladosporium punctulatum* Sacc.

on *Euonymus japonicus*:	Killarney, Kerry, 6/'35;
on do.	Foxrock, Dublin, 9/'32: Prof. J. Doyle.

Polythrincium Trifolii Kunze

on *Trifolium repens*:	Dingle, Dublin, 10/'32;
on do.	Boyne Valley, Louth, 7/'33.

**Cercospora beticola* Sacc.
on *Beta maritima*: Baltray, Louth, 10/'35.

Cercospora Resedae Fuck.
on *Reseda luteola*: Dingle, Dublin, 10/'33.

**Cercospora Scandicearum* Magn.
on *Caucalis Anthriscus*: Mullingar, Westmeath, 7/'35.

**Heterosporium Magnusianum* Jaap
on *Narthecium ossifragum*: Killough, Wicklow, 7/'35: Dr. M. O'Leary;
on do. Howth, Dublin, 7/'35;
on do. Mullingar, Westmeath, 7/'35.

**Coniothecium epidermidis* Cda.
on *Cytisus Laburnum*: Ranelagh, Dublin, 1/'35.

**Macrosporium Saponariae* Peck.
on *Saponaria officinalis*: Dromineer, Tipperary, 7/'33.

**Macrosporium sarcinaeforme* Cav.
on *Trifolium pratense*: Stillorgan, Dublin, 10/'34.

**Isariopsis albo-rosella* Sacc.
on *Cerastium vulgatum*: Killarney, Kerry, 6/'35;
on do. Mallow, Cork, 6/'35;
on do. Blessington, Wicklow, 7/'35;
on *C. viscosum*: Dingle, Dublin, 6/'33.

**Hirsutella Eleutheratorum* (Nees) Petch
on *Dromius linearis*: Portrane, Dublin, 3/'33: A. W. Stelfox, M.R.I.A.

**Cylindrocolla Urticae* (P.) Bon.
on *Urtica dioica*: Parknasilla, Kerry, 4/'34;
on do. Puckane, Tipperary, 4/'33;
on do. Turraun, Offaly, 4/'33;
on do. Dundrum, Dublin, 4/'33.

**Fusarium album* Sacc.
on *Ulmus montana*: Poulaphouca, Kildare, 8/'33;
on do. Powerscourt, Wicklow, 10/'33.

No. 40.

A COMPARISON OF SOME DUTCH AND IRISH POTATO MOSAIC VIRUSES.

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(Plate 9.)

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The following is an account of the examination of some potato mosaic diseases sent to us by Prof. Quanjer in 1933 for comparison with similar diseases occurring in Ireland. Material believed to correspond was sent to Wisconsin at the same time, an analysis of which has already been published by Koch and Johnson (4). The present examination was mainly confined to methods used in the routine examination of potatoes in the field, employing differential potato hosts and other plants. Most of the viruses proved familiar, and were identifiable in this way, but in the case of an unusual virus from the variety Monocraat it was necessary to make a more extensive study. A preliminary account of the work has already appeared (6).

Supermild mosaic in Bravo.

A single virus only was present which was found to agree in all respects with virus A, the following common characteristics of the two having been established :—

1. President, Arran Victory (Graft) ...	Faint mottle.
2. Arran Crest (Graft) ...	Faint mottle.
3. British Queen (Graft)	Typically a top necrosis, but may begin on intermediate leaves. Tuber necrosis.
4. Up-to-Date (Graft) ...	Foliage and tuber necrosis as in British Queen. Crinkle on scion from latent virus in Up-to-Date.
5. President containing virus X (Graft) ...	Severe mosaic equivalent to crinkle on stock and scion.
6. Irish Chieftain containing virus A (Graft)	No change.
7. Datura Stramonium ...	Negative.
8. Tobacco (White Burley) ...	Negative or doubtful; no X virus present.
9. Nicotiana rustica ...	Negative or doubtful; no X virus present.
10. Nicandra physaloides	Negative.
11. Myzus persicae ...	Transmitted virus readily to British Queen and Up-to-Date with same effects as above (see 3 and 4).
12. Solanum nodiflorum	Negative.

As stated, all 12 reactions correspond with those of virus A, and the probable absence of other viruses is indicated by the similar results following graft and insect infection (compare 11 with 3 and 4 above). The following viruses are excluded by the reaction number shown after each—various X-type viruses (2, 6, 7, 8, 9, 10); virus Y (1, 3, 4, 12); virus F (tuber blotch virus), (1); virus E (1, 2).

Quanjer (10) also identified with virus A the viruses of the "mild" and "intermediate" mosaics of Bravo, which appear to be identical with the present form. Koch and Johnson (4), on the other hand, who received presumably the same Bravo virus under the name of "simple mosaic," equated it with that of American mild mosaic, which they consider to be due to one virus. It is premature to pursue this question further at present, but Murphy and McKay (7) had already identified American mild mosaic with crinkle, in which the underlying viruses are X and A, and the conclusion of Koch and Johnson points in the same direction. The addition of virus A to any potato containing the healthy potato virus would produce a crinkle or intensified mosaic. Recent work at Glasnevin shows that authentic American mild mosaic contains an X-virus and an aphis-transmitted virus like A, which is at present under study.

Easily inoculable mosaic in Alpha.

At least two viruses were found present—an aphis-transmitted virus related to A, and a virus necrotic to President. The reactions were as follows:—

1. President (Graft) ...	Top necrosis, tuber necrosis.
2. Arran Crest (Graft and rub) ...	Top necrosis, tuber necrosis.
3. British Queen (Graft)	Top necrosis, tuber necrosis.
4. Up-to-Date (Graft) ...	Top (or middle) necrosis, tuber necrosis.
5. Datura Stramonium ...	Vein-clearing, vein-banding, interveinal mottle, severe.
6. Nicandra physaloides	Severe mottle and necrotic spotting.
7. Tobacco (White Burley) ...	Ringspot type of mottle.
8. Nicotiana rustica ...	Mottling.
9. Myzus persicae ...	Transmitted to President as a veinal mottle and to Up-to-Date as top-necrosis and tuber necrosis.
10. Solanum nodiflorum	The insect-transmitted virus caused vein-clearing and pronounced veinal mosaic, essentially as Y.

The presence of an X-virus is indicated by reactions 2, 5, 6, 7, 8. This was inoculated to *Datura*, after which it still caused top-necrosis by graft on President, but it was not further studied, as it appeared identical with Up-to-Date streak (reactions 1 and 3), and is, therefore, probably a mixture of the two viruses X and B, as Dykstra has shown (3). The insect-transmitted virus was responsible for reaction 4 (as well as 3 in part), and when first isolated was considered to be a variant of virus A, with a slightly more acropetal type of development. The two were compared on *Datura* (negative, no virus present),

tobacco (faint veinal mottle at times), British Queen, Up-to-Date, Great Scot, Kerr's Pink (top or mid-leaf necrosis and tuber necrosis in all), and Arran Banner, Arran Crest, Arran Victory, Duke of York, Epicure, Majestic, and President (faint veinal mottle on all, or negative). These correspond in all respects with the reactions of virus A, and no real difference between them could be established, though the Alpha virus gave rise to more severe tuber necrosis.

On the other hand, there were certain affinities with virus Y, and when it was discovered that *Solanum nodiflorum* distinguished between Y and A, the former producing a pronounced veinal mosaic (compare Fig. 3, Pl. 9), and A no symptoms, the present virus was tried on this host, and was found to produce symptoms essentially similar to those of Y (reaction 10).

The situation, therefore, is that the aphis-transmitted virus from Alpha resembles virus A on all the potato varieties tried, both on the foliage and especially in the matter of tuber necrosis, but resembles Y on the non-potato host. Under the circumstances, as we are dealing with a potato virus, and since the symptoms on potato are of practical importance, it is more convenient to consider it provisionally as a form of virus A, but showing some affinity with Y. There is no evidence of the presence of both viruses. The whole question, however, must be left somewhat open for the present.

Quanjer does not appear to have published on this disease. Koch and Johnson (4) found the viruses of mottle, ringspot, and possibly mild mosaic present. If mottle and ringspot are equated with virus X, and if it is allowed, as in the case of supermild mosaic, that A is a characteristic constituent of American mild mosaic, there is essential agreement between the results.

Rugose mosaic in Institut de Beauvais.

A single virus was found in this material corresponding to the general type of Y, but resulting in rugose mosaic and less necrosis and leaf-drop.

1. President (Graft) ... Veinal acropetal necrosis, leaf-drop, rugose type mosaic finally.
2. Arran Crest (Graft) ... Non-necrotic veinal mottle, slightly rugose on top.
3. British Queen (Graft) ... Veinal acropetal necrosis, leaf-drop, rugose type mosaic finally.
4. Up-to-Date (Graft) ... Slight acropetal necrosis, rugose type mosaic.
5. Arran Victory (Graft)... As Arran Crest.
6. Duke of York (Graft) ... Acropetal leaf yellowing and mosaic. Superficial necrosis on stem and petioles.
7. Epicure (Graft) ... Non-necrotic rugose mosaic.
8. Datura Stramonium ... Negative.
9. Nicandra physaloides ... Negative.
10. Tobacco (W. Burley) ... Vein-clearing and vein-banding.
11. Nicotiana rustica ... Vein-clearing and vein-banding.
12. Myzus persicae ... Transmitted to President with same symptoms as in case of graft.
13. Solanum nodiflorum ... Vein-clearing and pronounced veinal mosaic, exactly as Y (Fig. 3, Pl. 9).

The aphis-transmitted virus was found identical with the original on tobacco and the potato varieties President, Arran Crest, Arran Victory, and Epicure, the second year symptoms being typical rugose type mosaic in all cases. There was no tuber necrosis or missing, as happened with the Zeeland Blue and Alpha viruses. Koch and Johnson (4) found a single constituent in this material also, which they equated with the American veinband virus rather than Y. With this we are in general agreement owing to the slighter effect on President, British Queen, and Up-to-Date, although a fuller comparison would be desirable.

Latent virus in apparently healthy Zeeland Blue.

It was formerly thought that the responsible virus in this material was virus Y (9, 4, 6), but more than one virus is present, and the analysis is not yet complete. The reactions obtained were as follows:—

1. President (Graft) ... Veinal necrosis, typically acropetal and beginning on mid-leaves, but variable, leaf-drop, tuber necrosis.
2. Arran Crest (Graft) ... Veinal or spot-like acropetal necrosis of mid- to upper leaves, leaf-drop, tuber necrosis.
3. British Queen (Graft) ... Typically severe acropetal necrosis of mid-leaves, sometimes acronecrosis, leaf-drop, tuber necrosis.
4. Up-to-Date (Graft) ... Veinal acropetal necrosis of lower or mid-leaves (or axillary shoots), leaf-drop. No tuber necrosis.
5. Arran Victory (Graft) ... Acropetal necrosis of mid-leaves, sometimes acronecrosis, tuber necrosis.
6. Duke of York (Graft) ... Veinal acropetal necrosis of middle leaves, leaf-drop, tubers clean.
7. Epicure (Graft) ... Severe top necrosis, tuber necrosis.
8. Datura Stramonium ... Apparently negative at first, mottling in later trials.
9. Nicandra physaloides ... Apparently negative.
10. Tobacco (White Burley) Vein-clearing and vein-banding.
11. Nicotiana rustica .... No definite symptoms.
12. Myzus persicae ... Transmitted to President as veinal mottle and rust of lower leaves followed by veinal necrosis and acropetal leaf-drop. Tuber necrosis.
13. Solanum nodiflorum ... Sap inoculation from Zeeland Blue gave vein-clearing and vein-banding, like the effect of Y but distinguishable from it (Fig. 4, Pl. 9). The aphis-transmitted virus gave no symptoms up to the present, thus resembling virus A.

An X-type virus is now present in this material, as shown by reactions 7 and 8, but in the earlier trials in 1933 and 1934 this was not so clear, especially

as the effect on Arran Crest was not considered a typical top necrosis, and there may perhaps be room for a certain doubt if X was present from the beginning.

The type of necrosis produced on potato foliage by Zeeland Blue has always been variable. In three different varieties (President, British Queen, and Arran Victory) it produced both top and mid-leaf or bottom necrosis at different times, a result which depends on the age of the grafted plant, for when young and old British Queen plants were grafted at the same time the younger showed severe top necrosis, and the older a more indeterminate necrosis, mainly of the acropetal type. In Arran Victory and Arran Crest the type was also indeterminate, but it began near the tip, and might almost be said to be a top necrosis. In certain cases (Up-to-Date) the infection first showed on the lowest axillary shoot springing from the grafted stem, but on the top of this. The typical development, however, is considered to be acropetal, but the variable nature recalls the effects of virus A.

Although the analysis is not complete, there is now evidence of the presence of three viruses in the Zeeland Blue material:—

(1) An X-virus, as shown by reactions 7, 8, and probably 2.

(2) A virus transmitted by *Myzus persicae* which corresponds, so far as the examination has gone, most nearly with virus A, producing mild vein-clearing and vein-banding on tobacco, no symptoms on *Solanum nodiflorum*, and practically no foliage symptoms on Arran Crest, but a fine necrotic specking of the tubers. The last reaction, as one of us (Loughnane) has discovered, appears to be diagnostic for virus A, and both it and the second distinguish A from Y. On the other hand, the effect on President is a very severe leaf-drop, like that of Y, but more severe, and it will be necessary to determine the effects on a range of potato varieties before deciding whether the closest relationship may not be with the latter virus.

(3) Sap inoculation from the original Zeeland Blue to *Solanum nodiflorum* proved the virus to be more infectious than Y, and to possess a shorter incubation period (minimum, 5 to 9 days compared with about 20 days for Y), the symptoms being somewhat faint vein-clearing passing into a diffuse speckled mosaic and finally a sort of vein-banding. In a single case the mosaic was of a more pronounced type. These effects are quite unlike those of the aphis-transmitted virus, which in parallel inoculations produced no symptoms on *S. nodiflorum*, but may perhaps be due to the combination of this with X. They somewhat resembled the effects of Y, which produced in parallel trials on the same host a brilliant vein-clearing and veinal mosaic (Pl. 9, Fig. 3), but were distinguishable by more rapid development, fainter vein-clearing, and a more diffuse and milder vein-banding mosaic (Pl. 9, Fig. 4). It may possibly be necessary to assume the presence of a third virus, which has not yet been isolated. It is uncertain which virus is to be held responsible for the

variable type of foliage necrosis on potato varieties, and for the symptoms on Duke of York and on the tubers of Arran Victory.

Koch and Johnson (4) obtained symptoms like those of Y on tobacco, and leaf-drop on potato, and considered that a single virus was present, which they equated with Y.

Latent virus in Monocraat.

A single virus of a very interesting nature was found in this material which had never been encountered alone in any Irish variety, but after much work had been done on it in 1934, affinities were discovered with the tuber blotch virus, or virus F (2), which had just been isolated by Loughnane and Clinch out of interveinal mosaic (5), and the identity of the two was established in 1935. The reactions of the Monocraat virus were as follows:—

1. President (Graft) ... Negative or faint veiled yellow mosaic on lower leaves, tuber necrosis.
2. Arran Crest (Graft) ... Faint veiled yellow mosaic on lower leaves beginning as interveinal mottle, no tuber necrosis.
3. British Queen (Graft) ... As Arran Crest.
4. Up-to-Date (Graft) ... No symptoms, no tuber necrosis.
5. Datura Stramonium ... Carried without symptoms.
6. Nicandra physaloides ... Negative.
7. Tobacco (W. Burley) ... Carried as a rule or faint nebulous mottle in top, beginning as vein-clearing after 14 days.
8. Nicotiana rustica ... Negative.
9. Solanum nodiflorum ... Characteristic local lesions in 8 days, or more, consisting of pale areas with brown or purple margins following by vein-clearing on top in 11 days and faint mosaic lower down. Plants stop growth and become dark green, lowest leaves become purplish or rusty all over, yellow and drop, and virus may not become systemic.
10. Capsicum annuum ... Clear local symptoms consisting of pale or yellow circular or elongated areas with brown margins, forming a network. Leaf turns bronze, curls and drops. Mosaic and necrosis on top later.
11. Solanum Dulcamara ... Vein-clearing, faint diffuse mosaic with interveinal necrosis and some leaf-drop, or negative.
12. Solanum racemosum ... Carried without symptoms.
13. Petunia ... ... Carried without symptoms.

On account of the generally negative nature of the virus a number of other possible hosts were tried, the best of which proved to be *Solanum nodiflorum* and *Capsicum annuum*, on which clear and characteristic symptoms are produced. The potato varieties Dunbar Yeoman and Majestic also show very characteristic primary symptoms, consisting of a rusty wilt of the lower leaves (Fig. 1, Pl. 9), and secondary symptoms of small yellow spots on the lower leaves. Monocraat shows similar but fainter spots (Fig. 2, Pl. 9).

As stated, the virus was found closely similar in symptoms to, and indistinguishable in its properties from, the tuber blotch virus (virus F), and a full comparative account of the two is given in a separate paper by Clinch, Loughnane, and Murphy (2).

Quanjer does not appear to have published anything regarding this disease. Koch and Johnson (4) obtained leaf-drop and mottling on potato, and an uncertain type of ring-spot on tobacco from the Dutch Monocraat, and concluded that two viruses were present—a sort of ring-spot and an unidentified leaf-drop virus, but no proof was given that a single agent might not be responsible for both effects.

Latent virus in Magdeburger Blaue.

The characteristic virus in this material was found to be a necrotic type, accompanying X, the reactions being as follows:—

1. President (Graft)	...	Severe top necrosis, tuber necrosis. In second generation plants fail, or may show non-necrotic mosaic.
2. Arran Crest (Graft)	...	Severe top necrosis, tuber necrosis. Virus frequently does not become systemic.
3. British Queen (Graft)	...	Severe top necrosis, tuber necrosis. Virus frequently not systemic.
4. Up-to-Date (Graft)	...	No change.
5. Datura Stramonium	...	Vein-clearing, vein-banding, and interveinal mottle, severe.
6. Nicandra physaloides	...	Severe mottle and necrotic spotting.
7. Tobacco (W. Burley)	...	Ring-spot and necrotic spotting, severe.
8. Nicotiana rustica	...	Mottle becoming necrotic, severe.
9. Myzus persicae	...	No transmission.

An X-virus is indicated according to reactions 1, 2, 5, 6, 7, 8, accompanied by an acronecrotic form (reactions 1, 3, 4), probably corresponding to Up-to-Date streak virus (3), but more severe than the latter. The phenomenon described above in President, in which an initial top necrosis became a non-necrotic mosaic in that variety, has also been described by Oortwijn Botjes (1) and Quanjer (10), and has been attributed by the former to attenuation, and by the latter to the presence of two viruses and the elimination of the necrotic one, as often happens. The virus of Magdeburger Blaue was found identical on non-potato hosts, as well as on potatoes, with the non-aphis part of the easily inoculable

mosaic in Alpha (which contains an aphis-transmitted variant of A in addition), but the potato (Bliss Triumph) used by Koch and Johnson indicated some difference, as leaf-drop developed in the former case. This probably indicates that a still further non-aphis virus may be present here besides those in Alpha.

Interveinal mosaic in Bravo.

This disease, which was a well-marked interveinal mosaic, was found to show all the characteristics of Irish interveinal mosaic, and is, therefore, undoubtedly a complex, although the constituents were not separated. The reactions obtained were as follows:—

1. President (Graft)	...	Interveinal mosaic, tuber necrosis.
2. Arran Crest (Graft)	...	Severe top necrosis, fatal; tuber necrosis.
3. British Queen (Graft)	...	Interveinal mosaic.
4. Up-to-Date (Graft)	...	No change.
5. Majestic (Graft)	...	Rusty wilt of lower leaves as in case of tuber blotch virus (virus F), followed by interveinal mosaic.
6. Datura Stramonium	...	Vein-clearing, vein-banding, interveinal mottle, severe.
7. Nicandra physaloides	...	Moderately severe mottle.
8. Tobacco (W. Burley)	...	Ring-spot and necrotic spotting, severe.
9. Nicotiana rustica	...	Mottle.
10. Myzus persicae	...	Not tried.

These results indicate the presence of an X-virus non-necrotic to most potato varieties, except the Arran Crest group, with mottling of a pronounced and clearly interveinal character. The disease corresponds in appearance to that originally described and distributed by Quanjer (8) as interveinal mosaic, and to interveinal mosaic as understood in Ireland, all three of which produce the same necrosis in tubers of President and the same effect on Majestic (reactions 1 and 5). Work in this laboratory (5, 2) has recently shown that two viruses are involved, which have been isolated, an X-virus and an aphis-transmitted tuber-blotch virus (virus F), which accentuate each other, and produce a marked interveinal mottle. Koch and Johnson obtained from corresponding Dutch material, besides mottle and ring-spot, an unidentified virus, which probably corresponds to the tuber-blotch constituent.

The name interveinal mosaic has more recently been used by Quanjer (10) and his school in another sense, as the opposite of the veinal mottling characteristic of virus A or Y—in other words, as synonymous with mosaic due to X-infection. These mosaics are less pronounced than the original interveinal, and of a different type, since they contain no tuber-blotch element, and it would be better not to use this description for them, but some alternative, such as non-veinal mosaic.

Crinkle mosaic in Bravo (called in America mosaic).

This disease was found identical with crinkle as understood in Ireland, the same two viruses being present, namely, X and A. The reactions obtained were as follows:—

1. President (Graft)	...	Mosaic followed by typical crinkle.
2. Arran Crest (Graft)	...	————
3. British Queen (Graft)	...	Necrotic disease as in case of virus A or crinkle.
4. Up-to-Date (Graft)	...	Top or mid-leaf necrosis, tuber necrosis, fatal.
5. Datura Stramonium	...	Vein-clearing, vein-banding, interveinal mottle, severe.
6. Nicandra physaloides	...	Moderate mottle.
7. Tobacco (W. Burley)	...	Ring-spot and necrotic spotting, severe.
8. Nicotiana rustica	...	Negative.
9. Myzus persicae	...	Transmitted to President as a veinal mottle, like virus A, and to Up-to-Date as mid-leaf necrosis.
10. Solanum nodiflorum	...	Negative.

It is evident, owing to the different results got by insect and graft, that more than one virus was present, namely, an X-virus (reactions 5, 6, 7) and an aphis-transmitted virus corresponding in all respects with A (reactions 3, 4, 9, 10). Koch and Johnson, however, analysing what was presumably the same material sent them as "(?) mosaic," secured mottling on potato and infection on tobacco without symptoms, results which cannot easily be reconciled with those given above.

DISCUSSION.

The outstanding feature is the small number and cosmopolitan nature of the viruses present in this material, which may probably be taken to be a representative sample of Dutch potato mosaics. They correspond almost exactly with the viruses to be found in similar material in Ireland, and give rise to three groups of diseases—(1) those due to forms of X alone; (2) those due to forms of Y, forms of A, forms of F, or the vein-banding virus alone, all of which are aphis-transmitted (2); and (3) those due to combinations of X and Y, X and A, or X and F, and apparently also X and B, as the following summary shows:—

Disease.		*Viruses present.*
Supermild mosaic (Bravo)	...	A.
Mosaic easily inoculable (Alpha)	...	X, B, and form of A.
Rugose mosaic (Institut de Beauvais)	...	Vein-bending virus.
Latent virus in Zeeland Blue	...	X and form of Y or A, and possibly an unidentified virus.
Latent virus in Monocraat	...	F (tuber-blotch virus).
Latent virus in Magdeburger Blaue	...	X and B.
Interveinal mosaic (Bravo)	...	X and F.
Crinkle mosaic (Bravo)	...	X and A.

At least one other combination is also possible, namely, A and F, resulting in a yellow mosaic of the lower leaves, like aucuba mosaic, but apparently distinct (2). With these additions the list represents the more important potato mosaic diseases of Holland and Ireland, and probably of north-western Europe generally, and may be considered an encouragingly short one. The complexity which has arisen cannot be attributed to a great multiplicity of viruses, but rather to the protean reactions of potato varieties to a particular virus, to the occurrence of numerous forms of the same virus, to national systems of nomenclature, and to the virus complexes. Experimental work emphasises unduly the varied effects of a virus on different varieties; for example, the top necrosis produced by virus X on Arran Crest or Epicure, a useful diagnostic character which has been employed since 1927, practically does not occur in the field, and the characteristic symptom picture on other varieties is at most an extremely slight mottle, for which the name simple mosaic is appropriate. The same holds of viruses necrotic to other varieties, resulting in streak, for, after a primary reaction of varying violence, the tubers produce plants which may appear healthy or show faint mosaic only, as in Irish Queen, Majestic, and President. In other cases the tubers or plants die, which also leads to the disappearance of the streak from the crop. The necrotic foliage effects of virus A, by which it is recognised in the laboratory, are not seen in the field either, and plants which may have shown them recover later, so that the only symptoms visible are a faint veinal mosaic at most, or crinkle when X is present in addition. The effects of virus Y are perhaps more variable, consisting of primary symptoms of streak and leaf-drop on intolerant varieties, followed by veinal mosaic, or by rugose mosaic if X is present.

The discovery of two viruses intermediate between Y and A in the present study raises very important questions concerning the independence of the new forms or the mergence of one of them, perhaps, in an A-group and the other in a Y-group, analogous to the group of X viruses. For example, the aphis-transmitted virus from Alpha is most like A, though not quite identical, and it is uncertain at present whether to regard it as independent or as a form of A. The corresponding virus from Zeeland Blue is in some ways more like Y, though possessing other properties like A, and it is a question, therefore, whether to consider it a form of Y, or a form of A, or independent. This question is being further studied at present.

Furthermore, the new viruses emphasise the relationship between Y and A, and open up the question whether, if a series of intergrading forms exists between them, they should not be considered practically identical. The evidence available at present is opposed to such a view. The effects of Y and A, both alone and in combination with X, are so distinct on the foliage and tubers of a whole series of potato varieties that separate names would have to be retained for the diseases even if the viruses were considered the same. Virus Y causes leaf-drop or acropetal veinal mosaic on intolerant varieties, no tuber necrosis, and rugose mosaic in combination with X. Virus A causes a more indeterminate top or mid-leaf necrosis on the intolerant varieties, British Queen, Kerr's Pink, Up-to-Date, Great Scot (which incidentally either die or recover

from the disease), tuber necrosis in the same varieties, and produces crinkle (or American mild mosaic) in combination with X. The viruses are also distinct on *Solanum nodiflorum*, on which Y produces a pronounced veinal mosaic (Fig. 3, Pl. 9), and A no symptoms. They also differ in their distribution. Furthermore, the prior presence of A in *S. nodiflorum* does not protect against a subsequent inoculation with Y, and the same is true of potatoes in nature, for Irish Chieftain carrying A becomes naturally infected with Y.

The present work, however, throws a new light on viruses Y and A and tends to emphasise their relationship. It is believed that in any natural system of classification they must be placed in the same broad group, a fact which does not imply identity. In Quanjer's system of classification emphasis is placed on the type of necrosis produced on potato foliage, and on this criterion there is a tendency to separate the two, because Y always causes acropetal necrosis, but that caused by A is typically acronecrosis, although more variable. It would be easy to over-emphasise this point, especially since the necrotic effect of A can be varied at will to a considerable extent, for when young plants are grafted a fatal acronecrosis follows, but on older plants of the same variety the necrosis may begin mid-way or near the tip. This matter of classification is dealt with at more length elsewhere (2).

The viruses X, B, Y, A, F and vein-banding appear to underlie most potato mosaics of favourable maritime climates. The very best districts show a minimum of the aphis-borne group, and in these places A is more abundant than the Y type. The viruses survive indefinitely under these conditions, the balance between them and the potato plant, between the propagating power of the host and the destructive power of the virus, being so adjusted that infected plants and varieties survive for long periods. Remnants of varieties still exist in Ireland which were common before the coming of *Phytophthora infestans* in 1845, and it is the rule that these are completely infected with mosaic. Plants containing crinkle, simple, aucuba, and other mosaics have been grown under observation at Glasnevin from 1923 or 1925 until 1936 without either recovery, death, or other change.

It is not possible at present to extend this generalisation to other countries, but the work of Koch and Johnson (4) holds out the hope that the facts are essentially the same in many other places, and this is more likely to be the case where conditions are similar, that is, in well-marked ocean or mountain climates. In continental areas, on the other hand, the indications are that, in addition to the maritime forms, some of which appear to be universal, other viruses are commonly implicated in potato degeneration, so that the situation is not so simple as here. The practical absence from N.W. Europe of many serious American affections must be attributable to failure to maintain the requisite balance between virus and potato, as a result of which they die out, for it is practically certain that most of them must have been introduced in tubers at some time, as, indeed, remnants of such diseases as witches' broom show.

SUMMARY.

Examination of Dutch potato mosaic diseases, carried out in conjunction with similar work in America, showed the presence of viruses X, B, Y, A, F and vein-banding virus, occurring alone and in combinations (List, p. 427).

Symptoms in some cases were absent (X, Y and F) and in others corresponded to those of simple mosaic (X), veinal mosaic (Y or A), rugose mosaic or leaf-drop (X + Y), crinkle (X + A), and interveinal mosaic (X + F).

These viruses and diseases are the same as those common in Ireland, and probably in N.W. Europe generally, but others are important in continental areas.

Other viruses were found which were similar to A or Y but not identical. It is concluded that Y and A are distinct from each other, but that each may be the type of a smaller group of closely related or practically identical viruses, analogous to the X-viruses.

Virus Y caused pronounced veinal mosaic on *Solanum nodiflorum* on which A produced no symptoms. This plant also differentiated the viruses related to A and Y, as well as virus F, and proved a useful new differential host.

EXPLANATION OF PLATE 9.

FIG. 1.—Primary symptoms of the Monocraat virus (virus F) on Majestic, consisting of a terminal rusty wilt of the lower leaves. The secondary symptoms consist of a faint aucuba-like mosaic of the lower leaves.

FIG. 2.—Symptoms of the Monocraat virus (F) on Monocraat, consisting of a few small yellow spots on the lower leaves.

FIG. 3.—Sap inoculation from Institut de Beauvais mosaic on *Solanum nodiflorum*. Y from Smith and from an Irish source produced an identical effect.

FIG. 4.—Sap inoculation from Zeeland Blue mosaic on *Solanum nodiflorum*. The effect is unlike that of Y or A, but resembles more that of American rugose mosaic.

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FIG. 1.

FIG. 2.

FIG. 3. FIG. 4.

No. 41.

A STUDY OF THE AUCUBA OR YELLOW MOSAICS OF THE POTATO.

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Introduction.

Quanjer was the first to describe the aucuba mosaic disease on potato plants, and named it thus on account of its resemblance to *Aucuba japonica* (aucuba mosaic of tomato, although similarly named, is due to a different virus). He showed that the potato disease could be transferred by grafting to other potato varieties and to tomato, *Solanum nigrum*, and *Solanum Dulcamara*, all of which showed similar symptoms, and to tobacco, *Atropa Belladonna*, *Datura Stramonium*, and *Hyoscyamus niger*, which showed none but which were proved to be carriers (20, 21).

In 1926, Atanasoff stated that netnecrosis (first described by Orton in America in 1914) was a tuber symptom of aucuba mosaic (1). According to Atanasoff's illustrations, netnecrosis is a pathological condition in which the parenchymatous tissues of the tuber become necrotic, but the vascular tissue is not involved. He grafted Roode Star (showing netnecrosis in the tubers and slight aucuba mosaic mottle) on eight other potato varieties, all of which developed aucuba mosaic mottle of varying degree in the foliage, excepting Bravo, and, in addition, Duke of York developed netnecrosis in the tubers. Atanasoff, therefore, identified tuber necrosis as a symptom of aucuba mosaic, and to confirm this grafted Quanjer's aucuba mosaic in May Queen on 10 tubers of Duke of York, all of which developed aucuba mosaic in the foliage and necrosis in the tubers.

In 1929, Elze and Quanjer (8), in agreement with American workers, identified netnecrosis as the tuber condition occurring in certain American potato varieties (e.g., Green Mountain) affected with leaf-roll. In the same year, Quanjer, Thung, and Elze (24) substituted the name pseudonetnecrosis instead of netnecrosis for the tuber condition occurring in Roode Star, which Atanasoff had regarded as a symptom of aucuba mosaic. They stated also that pseudonetnecrosis had been observed by them in Roode Star and several other varieties unaccompanied by foliage symptoms, and, conversely, that Early Regent received from Prof. Murphy showed aucuba mosaic without tuber necrosis. Accordingly, they concluded that Atanasoff in his experiments had been dealing with a mixture of aucuba mosaic and pseudonetnecrosis, and that he was incorrect in regarding the latter as a symptom of aucuba mosaic.

Reference should be made to the American disease known as potato calico, which was first described by Hungerford (10) as non-infectious and tuber-perpetuated. The symptoms consist of large irregular yellow or white patches on the foliage, and a reduction in yield of the tubers. Recent work by Porter in California (19) reveals that the disease is transmissible by inoculation of unfiltered sap to potato (var. White Rose), tomato, *Capsicum annuum*, egg plant, *Datura*, and *Petunia* spp., but that tobacco failed to become infected under the same conditions. The symptoms observed on these hosts, however, are not those of calico alone, as the inoculum used contained the "healthy potato virus" in addition, but the presence of calico was demonstrated by recovery on potato. Porter also records successful transmission of the virus by the aphis *Macrosiphum solanifolii*.

Interveinal mosaic of potato was first described by Quanjer (20) in 1921, and further accounts of its reactions have been given by Murphy and McKay (14), Smith (27), and Clinch and Loughnane (5). Smith (28) suggested that the disease was a complex of the X and Y viruses, but it was proved in this laboratory (5) that, although X was present, there was no evidence of Y. On the other hand, there were indications of the presence of another virus, owing to the occurrence of tuber necrosis, and in due course this was isolated, and found to differ from both X and Y, but bore a relationship to aucuba mosaic. It was temporarily named the "tuber blotch virus" by Loughnane and Clinch in 1935 (13).

Koch and Johnson (12), in the meanwhile, reported the isolation of a virus from interveinal mosaic (received from Glasnevin), which was new to them, and which they called the "potato streak virus." They described the reactions of the virus on tobacco and on the American potato varieties Green Mountain and Bliss Triumph, and gave its thermal death point and longevity *in vitro*. Although these varieties had not been used here at that time, it was considered likely, for reasons which were given, that the virus in question was probably identical with the tuber blotch virus (13), but during the past year additional facts have come to light which complicate the issue and render its identity uncertain.

At the same time, while this work on the aucuba mosaic and tuber blotch viruses was in progress, another virus was found by Murphy and Loughnane (16) in latent condition in the variety Monocraat, which had been supplied by Prof. Quanjer for comparative purposes. This was recognised to be a new form, but was later found identical, or practically so, with the tuber blotch element which had just been isolated from interveinal mosaic.

Work on these three viruses was at first carried on independently until their relationships were gradually discovered. It is the purpose of the present joint paper to describe the general properties and reactions of the aucuba mosaic, tuber blotch and Monocraat viruses and to indicate their relationship to other potato viruses.

Aucuba Mosaic.

Source of material.—The aucuba mosaic used in these experiments was isolated in Ireland in 1924, and has been propagated since in the varieties Early Regent and President without showing variation. Affected plants grow normally and give good yields, but the leaves, more particularly the lower and subsequently the middle ones, display numerous bright yellow spots, usually rounded in shape, and varying in size up to about 0·5 cm., which may coalesce to form large yellow or whitish patches. In addition, the tubers of President, but not those of Early Regent, develop a necrosis of the parenchymatous tissues which varies in extent according to conditions.

Pathological effects.—An account of the microscopic examination of leaves of President affected with aucuba mosaic has already been given (4), and further observations have confirmed previous conclusions. When young mottled leaves were tested for starch it was found that recently developed chlorotic spots stained more deeply with iodine than did the remainder of the leaf, particularly in the early morning. When older leaves were examined, some of the yellow areas stained deeply with iodine whether the leaves were cut in the morning or evening, but the most severely affected patches were devoid of starch. Inhibited carbohydrate translocation is, therefore, one of the initial pathological effects of aucuba mosaic. Ultimately, the affected plastids break down, setting free fat droplets in the cells.

Tuber necrosis occurs in the parenchymatous cells of both cortex and pith, as a rule, and is usually visible externally as irregularly shaped brown patches, which later develop into sunken dry brown areas (Fig. 2A). It begins first towards the heel end of the tuber, and does not attack the vascular tissue or eyes. The necrotic patches consist of groups of misshapen dead cells with brown granular contents and swollen brown and disintegrating walls, surrounded by a zone of translucent tissue containing little or no starch, in which incipient cork formation is observed. The centre of the spot is occupied by a small group of cells filled with large starch grains. The necrosis develops during storage, and is favoured by darkness and high temperatures, and particularly by a turgid condition.

TABLE 1.

Symptoms of Aucuba Mosaic in Different Potato Varieties.

VARIETY.	FOLIAGE SYMPTOMS.	TUBER SYMPTOMS.
President	Bright yellow spots on lower leaves.	Necrosis
Early Regent ...	do.	Nil
Majestic	do.	Necrosis
Champion	do.	Necrosis
Epicure	Brilliant and extensive yellow spotting on lower and middle leaves.	Nil
Arran Crest ...	do.	Nil
Great Scot	do.	Necrosis
Dunbar Yeoman ...	do.	Necrosis
Arran Banner ...	do.	Nil
Arran Victory ...	Large yellow blister-like spots on lower leaves.	Nil
British Queen ...	Wilting and "drying-out" of the tips of lower leaves followed by a pronounced yellow mottle.	Necrosis.
Roode Star ...	Variable—mild and transient diffuse yellowish mottle confined to bottom leaves, or yellow blistering at the tips of these leaves.	Necrosis may occur. (Symptom erratic)
Up-to-date ... ... (contains virus X)	Bright yellow mottling on lower leaves.	Nil
Irish Chieftain ... (contains virus A)	Brilliant yellow mottle reaching to top of plant.	Nil

It will be seen that this tuber necrosis corresponds to the condition called pseudonetnecrosis by Quanjer, Thung, and Elze (24), the microscopic details of which have been described by Kerling (11). Quanjer and his co-workers recorded that pseudonetnecrosis developed during storage, and that its development was accelerated by any rise in temperature. As already stated, they consider the disease to be unrelated to aucuba mosaic. This point is discussed further on.

Symptoms on potato.—The symptoms of aucuba mosaic in different potato varieties are given in Table 1. In all the potato varieties tested aucuba mosaic causes characteristic symptoms in the foliage, i.e., a bright yellow variegation, which, however variable in extent, is clearly distinguishable from the type of mottling characteristic of virus X or virus A. Furthermore, aucuba mosaic always appears first on the lower leaves, and is sometimes confined to them, but in Irish Chieftain, which is exceptional, it develops all over the plant and is particularly brilliant (Fig. 3). The presence of virus A is believed to be responsible for the exaggeration of the mottle in this case. Tuber necrosis, as already described, occurs in seven of the fourteen varieties examined. It is most pronounced in President, and may be very mild in other varieties. In Roode Star tuber necrosis occurs, but not consistently, and it is milder than

the necrosis produced in this variety by the Dutch Monocraat virus, which is described further on.

Sap transmission to various hosts.—Although generally regarded as being non-inoculable, aucuba mosaic is readily sap-transmissible to potato and to other solanaceous hosts.

Four young President potato plants were inoculated by rubbing infective sap on the lower leaves with a ground glass spatula. Two of them developed aucuba mosaic symptoms in the foliage and tubers; the other two remained healthy in appearance, but the tubers were necrotic, and the plants to which they gave rise in the following season showed typical aucuba mosaic mottle.

Upwards of fifty plants of *Datura Stramonium* were inoculated without the appearance of symptoms, but when grafted back on healthy President, typical symptoms of aucuba mosaic always developed in the potato foliage and tubers (Fig. 1). On rare occasions such *Datura* scions showed a few rounded yellow spots on the lower leaves, accompanied by a darkening in colour of the tissue along the veins, so that the plant is not a perfect carrier under all conditions. It is very susceptible, however, and infection rarely fails.

Tobacco (var. White Burley) is also readily inoculable, but shows no symptoms. The presence of the virus was shown by inoculating back to healthy President, when typical aucuba mosaic symptoms developed in the potato plants.

On tomato (var. Kondine Red). Symptoms consist of small rounded yellow spots which are confined to the lower leaves, and develop best on soft young plants. The disease was recovered unchanged from tomato by grafting on President.

On *Petunia* (var. Rosy Morn) no symptoms followed inoculation, but the presence of the virus was confirmed by grafting on President potato.

On the discovery of the distinctive reaction of the Monocraat virus on *Solanum nodiflorum,* this plant was used for aucuba mosaic, from which practically identical symptoms were obtained. These consisted of the appearance after 7 to 10 days of round local lesions, which were pale at first and afterwards turned purple (Fig. 10). Systemic symptoms, which did not always follow, began four or five days later with vein-clearing on the leaves above the inoculated ones, developing into interveinal chlorosis, followed by general purple discolouration or purple fringed rings like the local lesions (Fig. 11). Finally, the leaves yellowed and dropped off. In some cases the growing point was attacked and the plant killed. When the inoculated leaves dropped off quickly there were usually no further symptoms. The virus was recovered unchanged by grafting *Solanum nodiflorum* on potato.

Pepper (*Capsicum annuum*) was also first used in this work for the Monocraat virus, and when aucuba mosaic was tried on it identical symptoms were again obtained. Necrotic local lesions developed, followed by systemic symptoms on the next higher leaves, consisting of vein-clearing, developing into pale or necrotic interveinal mottle, puckering, distortion, and leaf-drop (Fig. 9). The infection progressed from leaf to leaf up the stem, but the growing point was not killed.

Insect Transmission Experiments.—An attempt to transmit aucuba mosaic by means of the aphis *Myzus persicae* was unsuccessful. In view of the effect of virus A in facilitating the transmission of the related tuber blotch virus, as described later, a similar attempt was also made with the combination aucuba mosaic and virus A, but with no better success. In each experiment the aphides were allowed to migrate freely from the sources to seventeen healthy sprouting President tubers, with the result that 11 of the 17 tubers exposed to virus A contracted that infection, but none of the 34 plants developed aucuba mosaic.

It is intended to extend this investigation to other species, particularly *Macrosiphum gei* (*M. solanifolii*), which has been reported as a vector of calico in America. Elze, using a variety of insects, including *Myzus persicae, M. pseudosolani, Aphis rhamni, Lygus pratensis,* etc., recorded failure to transmit aucuba mosaic (7).

Physical Properties.—The sap used in the following experiments was extracted from President plants infected with aucuba mosaic from the original Early Regent stock. The leaf material was cut up and ground in a mortar with the addition of 1 c.c. of sterile water to 1 g. of leaf material, except where otherwise stated. The macerated foliage was then squeezed through a piece of cotton cloth, yielding a green suspension, which is referred to as the crude sap.

The crude sap was drawn by suction through filter-paper pulp, and then successively through L 1, L 3, and L 5, Pasteur-Chamberland filter candles (previously tested and sterilized), the filtrates being inoculated to 6 *Datura* seedlings, which were subsequently grafted on potato, with the following results:—

Paper pulp filtrate	...	...	6/6 infected.
L 1 filtrate ...	...	...	3/6 infected.
L 3 and L 5 filtrates	...	...	0/6 infected.

5 c.c. lots of crude sap in thin-walled test tubes were heated for 10 minutes in a water-bath and then cooled rapidly in running water. Each sample was inoculated directly to *Solanum nodiflorum,* with the following result:—50° C., 4/5 plants infected; 54° C., 5/10 plants infected; 58° C., 6/10 plants infected; 60° C., 5/10 plants infected; 63° C., 2/10 plants infected; 65° C., 0/10 plants infected; 70° C., 0/5 plants infected.

The sap was expressed from the foliage of a vigorous young plant without addition of water, and diluted in the proportions 1/10, 1/100, 1/200, 1/500, and 1/1000 with distilled water. Each sample was inoculated to 5 seedlings of *Solanum nodiflorum,* with the result that all plants were infected at a dilution of 1/10, four at a dilution of 1/100, three at 1/200, and none at the other dilutions.

The crude sap was stored in stoppered bottles at 15° C. in the absence of light, and inoculated to the host plants at daily intervals. The limit of

survival under these conditions was less than four days—7/10 plants being infected after 1 day, 5/10 plants after 2 days, 2/10 plants after 3 days, and 0/10 after 4–6 days.

During the course of the foregoing experiments, no evidence that aucuba mosaic might be a complex due to two viruses was obtained. Following numerous inoculation experiments with untreated sap as well as with sap subjected to filtration, heating, and ageing, the disease, when returned to President potato, produced the typical foliage and tuber symptoms in that variety.

Tuber Blotch and Monocraat Viruses.

Source of tuber blotch material.—The virus, which has been known by the provisional name of tuber blotch in this laboratory, was isolated from the Glasnevin stock of interveinal mosaic in 1933 (13). Interveinal mosaic, as described in detail in a previous paper (5), causes typical X-symptoms in the foliage of potato, *Datura,* tobacco, etc., but in President (and other varieties) it produces, in addition to a conspicuous dark and light green mottling all over the plant, a certain amount of rusty necrosis in the lower leaves, and a necrosis in the tubers similar to, although generally more severe than, that caused by aucuba mosaic. In vigorous well-nourished plants the necrosis on the lower leaves may be slight, and may be replaced by occasional small round yellow spots. Interveinal mosaic of Irish origin and the corresponding Dutch disease received from Prof. Quanjer in 1925 showed the same symptoms, but the name interveinal mosaic is now sometimes used in Holland in a different sense (23, 16).

Isolation of the tuber blotch virus.—The original experiments on the insect transmission of interveinal mosaic gave negative results. When, however, virus A (14) was combined with interveinal mosaic in President tubers, which were then colonised with *Myzus persicae,* the aphides transmitted to healthy President not only virus A, but also a virus which caused conspicuous raised yellow areas on the lower leaves of the A-infected plants, together with necrosis in the tubers identical with that occurring in the interveinal mosaic source. No X-virus was transmitted. Virus A was then removed from the other insect-transmitted virus by inoculation to *Datura* (which is non-susceptible to A (5)), and the remaining fraction, to which the name "tuber blotch" was applied, was transferred to President potato by grafting. Conspicuous necrosis resulted in the President tubers (Fig. 8), but there were no foliage symptoms, excepting an occasional slight yellowish spotting at the tips of the lower leaves. As was discovered later, the conspicuous yellow mottle referred to above only occurs when the virus A and tuber blotch are combined.

By filtering the original interveinal mosaic sap through L 1, L 3, and L 5 Pasteur-Chamberland candles, it was found that the tuber blotch virus was partially removed by the L 1 candles, and completely so by the L 3 and L 5 candles, whereas the X component passed freely through the three. The

X-virus thus isolated, which corresponds to the "mosaic ex C" described in a previous paper (5), resembles the original interveinal mosaic in its foliage symptoms on young President plants, excepting that the rusty necrosis is absent from the lower leaves, but in older plants the symptoms are less severe, as the young growth appears free from mottle. The really distinguishing character, however, is the absence of necrosis from the tubers, but this feature is restored, together with foliage symptoms identical with the original interveinal mosaic, when the tuber blotch virus is introduced again. Although the latter of itself produces practically no symptoms on President, it has the effect of rendering the X-virus mottle more persistent and pronounced throughout the life of the plant, and is responsible for the rusty necrosis in the lower leaves.

Source of Monocraat virus.—The original Monocraat potato as received from Holland was a perfect carrier in most cases, but sometimes there was a trace of veiled yellow mosaic on the lower leaves (Fig. 5), especially in the field, and in one case tuber necrosis developed, which is apparently also Quanjer's experience. Infection experiments, however, showed that a virus was present, and this proved so like the tuber blotch virus that the two are described together.

Symptoms on potato.—In general, the two viruses are remarkably negative ones, and the foliage symptoms are exceedingly mild, especially under glass. Primary symptoms consist of a terminal and interveinal rustiness of the lower leaves in the case of one or two intolerant varieties, or more typically of a few small round yellow spots on the lower leaves, like veiled aucuba mosaic, and these effects are interchangeable, depending on conditions. The secondary effects are even less marked, especially in the greenhouse, for necrosis is usually absent, or nearly so, but the yellow spots show up more clearly in the field, especially early in the season (June), and are no doubt favoured by comparatively low temperatures, though they are not the direct effect of frost (15, 29, p. 307), for they occur in its absence, and are confined to plants containing this virus, healthy plants beside them being free. Later on, the further growth of the plant obscures the symptoms, for they remain confined to the lower leaves, which later yellow off, and except on close inspection the appearance presented is one of perfect health. In contrast, aucuba mosaic is generally more obvious, due to the yellow areas being more numerous and brighter, and to their development higher up on the plant.

Epicure, and especially Dunbar Yeoman, are the best diagnostic varieties. Following a graft the former shows a characteristic general yellowing of the leaves and stems, resulting in leaf-drop and premature death, and Dunbar Yeoman shows a bright yellow mottling (Fig. 7) or severe scorching of the lower leaves (Fig. 6), or both effects in succession. The necrosis begins as a burn of the tip or margin of a terminal leaflet, and later of the other leaflets, of a middle or lower leaf, rapidly extending inwards along the interveinal areas as a pale green or rusty wilt, and progressing acropetally on the plant. The leaves look as though scorched by fire, curve downwards, gradually turn rusty or yellow and die back, and hang or drop. Occasionally there may be slight lesions in the collenchyma of the stem. This variety also gives the best secondary symptoms

in the field, consisting of a non-necrotic yellow variegation of the tips, margins, and interveinal areas, of the lower and middle leaves, approximating in brightness to aucuba mosaic.

A large number of other varieties were infected by grafting, with results that varied from occasional yellow spots on the lower leaves, or nothing at all, to slight rusty wilt as on Dunbar Yeoman. The secondary symptoms were isolated non-necrotic yellow spots, similar to but much less pronounced than in aucuba mosaic, occurring in characteristic manner near the tips and margins of the lower leaves, and especially clear on British Queen, Roode Star, and President. The varieties infected were Alpha, Arran Banner, Arran Cairn, Arran Consul (N), Arran Pilot, Arran Crest, Arran Scout, Arran Victory (N), Ballydoon, British Queen (N), Champion (N), Di Vernon, Duke of York (N), Dunbar Cavalier (N), Eigenheimer, Great Scot (N), Kerr's Pink, King Edward, Majestic (N), President (N), Roode Star (N), Up-to-Date (N), and Zeeland Blue (N). In general, the effects of the Monocraat and tuber blotch viruses were identical, differing in degree rather than kind, but the former appeared to be more necrotic, producing primary symptoms of rusty wilt rather than mottling, on Majestic especially, and also Champion and Arran Banner, although there was no difference in the next generation. Necrosis in the tubers is a feature of both viruses, and the list of varieties (which is not regarded as final) in which one or other of them is known to have produced it is marked with an (N) above. The necrosis is of the same type as in aucuba mosaic, but more severe (e.g., in President and Roode Star), and the list includes a number of varieties such as Arran Victory, Up-to-Date, and Irish Chieftain, in which aucuba mosaic produces no tuber symptoms. Tuber necrosis is a good diagnostic symptom of these viruses when aucuba mosaic is excluded.

Another good diagnostic character is the effect of combining virus A with either the tuber blotch or Monocraat viruses. Both the latter viruses have been combined with A in Irish Chieftain, President, and Golden Wonder, with the same effect in all six cases, namely, the production of a much intensified bright yellow variegation (Fig. 4), which begins on the lower leaves and gradually extends almost to the top of the plant, especially in the second generation. Conversely, tuber blotch can be used to determine the presence of virus A. The latter has a corresponding effect in intensifying aucuba mosaic also, producing a very extensive and brilliant variegation, which extends to the top of the plant.

Sap transmission to various hosts.—Both viruses are very readily transmissible by sap, not only to other plants, but also to potatoes. The varieties Majestic and Dunbar Yeoman were thus infected with the Monocraat virus, with the same effects as by graft, and the virus was recovered by inoculation to *Solanum nodiflorum* and grafting on President, with the usual tuber symptoms. The tuber blotch virus was needled direct to President also. The effects on other plants are shown in Table 2.

TABLE 2.

Reactions on Non-potato Hosts.

	TUBER BLOTCH VIRUS.	MONOCRAAT VIRUS.
Tobacco White Burley	No symptoms (R).	No symptoms usually, but at times a clear faint interveinal mottle shows on top after 13–14 days. (R).
„ Nyassaland	———	No symptoms. (R)
„ Old Irish ...	———	do.
Nicotiana affinis ...	No symptoms.	do.
„ *glauca* ...	do.	do.
Tomato	do.	do.
Petunia	do.	do. (R)
Datura Stramonium ...	do. (R).	do. (R)
Solanum racemosum ...	———	do. (R)
Solanum Dulcamara ...	No symptoms actually seen but probably as Monocraat.	Definite vein-clearing on leaves next above rubbed ones under best conditions, lowest leaves curl, yellow, and drop. (R).
Solanum nodiflorum ...	Local lesions and vein-clearing above. Full description below.	Local lesions and vein-clearing above. Full description below. (R)
Capsicum annuum ...	Local lesions and mosaic above. Full description below.	Local lesions and mosaic above. Full description below. (R)

R = Virus recovered on potato or *S. nodiflorum* or both.

Diagnostic hosts.—A large variety of plants was tried in the hope of finding a good diagnostic host, and this was realised in *Solanum nodiflorum* and *Capsicum annuum*. The symptoms of both viruses on *Solanum nodiflorum* begin after 8 days as slight pale local lesions with brown or purple margins on the inoculated leaves. Three to five days later, if the virus becomes systemic, vein-clearing sets in on the leaves next above, developing acropetally, and showing most characteristically on the fourth or fifth leaf from the top. The plants stop growth, and turn a dull dark green. The lowest leaves rapidly yellow and drop, and the next higher leaves develop brown, purple-fringed spots, or a generalized rusty purple colour, and may wither from the tip backwards, and drop also. In some cases the virus does not become systemic, especially in cold weather, which is unsuitable for the plant. Shading appears to favour infection. There is no essential difference between the symptoms of the tuber blotch and Monocraat viruses and those of aucuba mosaic. The reactions of other viruses on *S. nodiflorum* are as follows: virus X may cause a diffuse mottle and is recovered unchanged, virus A produces no symptoms, and virus Y causes pale local lesions, acropetal veinal mosaic, and leaf-drop.

In *Capsicum* the symptoms are very similar, and usually conspicuous, consisting of pale areas on the inoculated leaves, which are typically elongate,

and situate between the sub-main veins, from which they are separated by a brown margin, or are small and round in shape and similarly margined. These leaves become bronzed, curl down, and fall off. Vein-clearing meanwhile appears on the next higher leaves, followed by clear mosaic, distortion, and leaf-drop, and though the leaves become progressively infected the plant survives indefinitely. All three viruses have the same appearance on this host.

So far as the other hosts are concerned, the remarkable feature is the number which the tuber blotch and Monocraat viruses infect, and the few which show symptoms. None of these plants differentiate these viruses, but aucuba mosaic is distinguished on *Solanum Dulcamara* and tomato by the development of bright yellow spots 1 to 3 mm. in diam. developing acropetally on the leaves above the inoculated ones.

Physical properties.—The principal properties of the two viruses are as follows:—

	Tuber blotch virus.	Monocraat virus.
Filterability L 1 filter ...	Passed.	Passed.
L 3 „ ...	Not passed.	Not passed.
L 5 „ ...	Not passed.	Not passed.
Thermal death point ...	63–65° C.	62·5° C.
Longevity in vitro (15·5° C.) ...	Survived 2–3 days.	Survived 3 but not 5 days.
Dilution (potato sap) ...	——	1 : 100.

Solanum nodiflorum was used for most of these experiments, and in addition the result was checked by grafting on President potato in the filtration test, in which the L 1 filtrate produced tuber necrosis, but not the L 3 or L 5 filtrates. The results show complete agreement.

Insect transmission (Myzus persicae).—These experiments had their origin in attempts to transmit interveinal mosaic by means of insects, and were carried out by allowing the insects to migrate freely from the sprouting infected tubers to healthy President tubers in the same dish during a period of about 30 days. No transmission of any virus was obtained in this way, and it was concluded that no insect-borne element was present. In one experiment, however, virus A was present in the source as well as interveinal mosaic, with the result that most of the experimental plants became infected with virus A, and a small proportion of them produced necrotic tubers in addition. The necrosis was similar to that associated with interveinal mosaic, and was evidently due to a separate virus, for it was possible to isolate it from virus A by passage through *Datura*. Incidentally, interveinal mosaic was reconstituted, with the same foliage and tuber symptoms, by combining the tuber spotting element with virus X again. The same experiment was next repeated with this tuber blotch

virus, as it was called, and virus A, with a like result. Table 3 gives the details of these experiments.

TABLE 3.

Transmission of tuber blotch virus by Myzus persicae.

Source of infection.	No. of healthy tubers used.	No. infected with—		
		Tuber blotch only.	Tuber blotch + Virus A.	Virus A.
Interveinal mosaic (X + tuber blotch) ...	11	0	0	—
Interveinal mosaic + virus A ...	28	0	4	17
Tuber blotch + virus A	20	0	14	18

The virus removed from the interveinal mosaic by the aphis is an essential constituent of the complex, as confirmed by subsequent synthesis. The role of virus A in facilitating its transmission is an extremely interesting question, no explanation of which can at present be given, but the subject is being further studied. Actually no insect transmission of the tuber blotch virus has been secured in the absence of virus A. It appears that there is little specific affinity between *Myzus persicae* and the former virus, as heavy infestations gave the best results, pointing probably to mechanical transmission, which the presence of the other virus appears to facilitate. Little corresponding work has been done on the Monocraat virus, and no insect transmission has yet been secured, but it has not yet been tried in the presence of virus A.

DISCUSSION.

According to Quanjer's description, pseudonetnecrosis is a disease which causes necrotic spots in the storage parenchyma, next to the external and internal phloem, of potato tubers without accompanying foliage symptoms, and he suspected that some potatoes acted as carriers. The disease was found to be sap- and aphis-transmissible, and Quanjer placed it in a special section (V) by itself (22, 23).

It is impossible from the available data to identify conclusively the tuber blotch and Monocraat viruses with the virus underlying pseudonetnecrosis (24), but since the latter disease causes the same type of tuber necrosis, and is sap- and aphis-transmissible, it is most probably caused by a similar virus. The fact that no foliage symptoms have been recorded by Quanjer and his co-workers in connection with the pseudonetnecrosis disease does not lessen this probability, for the symptoms of the tuber blotch and Monocraat viruses on potato foliage in general are mild and erratic in appearance, and the best

differential varieties, such as Dunbar Yeoman, Epicure, Majestic, and British Queen, were not used by the Dutch workers.

The identity of the tuber blotch and Monocraat viruses has already been indicated. There is an obvious relationship between aucuba mosaic and the tuber blotch virus type also, for they resemble each other in the following respects:—

(*a*) Readily transmissible by inoculation of infective sap.
(*b*) Similar symptoms in *Solanum nodiflorum* and *Capsicum annuum.*
(*c*) Carried symptomlessly by *Datura,* tobacco, and *Petunia.*
(*d*) Filterability, thermal death-point, longevity *in vitro,* and dilution end-point are similar.
(*e*) Similar general type of foliage symptoms, consisting typically of yellow variegation (or of primary rusting on intolerant varieties), always beginning on the lowest leaves.
(*f*) Produce a similar necrotic effect in the tubers of several potato varieties.

Omitting the negative results of insect transmission experiments with aucuba mosaic, it may be said that it is in the reactions on potato (as well as on some other hosts) that the greatest difference is apparent. Aucuba mosaic is readily distinguished from the others, especially in the greenhouse, by its conspicuous yellow variegation on all the potato varieties examined, excepting Roode Star, while the tuber blotch type is distinguished by its symptoms on Dunbar Yeoman, Majestic, and Epicure. The tuber blotch and Monocraat viruses, however, produce mild replicas of the yellow variegation on Dunbar Yeoman and British Queen, and the aucuba virus causes slight primary rusty wilt on British Queen, and all three viruses give rise to the same type of tuber necrosis. Hence it might be suggested that the relationship between them is either of the following—

(*a*) aucuba mosaic and the tuber blotch type are closely related members of the same group; or
(*b*) aucuba mosaic is a complex of the tuber blotch type and another virus which is responsible for the foliage symptoms, which was Quanjer's original view.

In view of the present results the second alternative is clearly untenable, among other reasons because the viruses of the tuber blotch type produce tuber necrosis on varieties not similarly affected by aucuba mosaic, and necrotic foliage symptoms on others, and because aucuba mosaic itself shows no evidence of complexity. It is concluded, therefore, that the virus of aucuba mosaic is closely related to the tuber blotch, Monocraat, and pseudonetnecrosis viruses, which are themselves probably identical, forming a natural group with many distinctive properties in common, which differ markedly from both the X and Y types.

Since the tuber blotch and aucuba viruses have now been adequately described in their symptoms and properties, and proof has been given that they are distinct from previously described forms, and are single entities, it is essential to give them distinctive names apart from the names of the diseases they cause. In the absence of a universally accepted numerical system it is thought best to continue the use of letters for the present, and accordingly the tuber blotch virus of potato, as here defined, is designated potato virus F, and the virus of aucuba mosaic of potato, as here defined, is designated potato virus G.

Although a new group is hereby created, the present work leads to a reduction of the number of genera of the potato mosaics, for Quanjer's list (23) may be simplified by the merging of "Section I. *Anecrotic mosaics*" (which includes only aucuba mosaic) and "Section V. *Pseudonetnecrosis*" (which includes only that virus disease) to form one group. Calico would be expected to find a place here also, but, although Bawden's virus D (2) superficially resembles the Monocraat virus in causing mid-leaf or acropetal foliar necrosis in certain potato varieties, these do not include those which react somewhat similarly with the Monocraat virus (e.g., Dunbar Yeoman and Majestic), and Bawden himself places virus D in or near the X group on account of the possession of a number of properties characteristic of X. These clearly distinguish it from the tuber blotch virus type. In this connection it is interesting to note that Chester (3) recently examined the serological reactions of a number of tobacco mosaic strains and potato mosaics. He found that aucuba mosaic of potato was a serological entity distinct from (*a*) potato X-virus, and (*b*) vein-banding (Y type), which themselves are serological entities.

Taking a general view of their properties and reactions, the potato mosaic viruses so far isolated appear to fall into three broad groups,[1] as follows :—

Group 1.—Viruses of the X type, which cause distinctive mosaic symptoms in tobacco, *Datura Stramonium*, *Petunia*, and other solanaceous hosts; produce acronecrosis on the potato variety Arran Crest; form crinkle when combined with virus A in potato varieties tolerant of that disease; are non-transmissible by *Myzus persicae*; and pass an L 3 Pasteur-Chamberland filter candle.

Virus X of Smith, mottle virus, ringspot virus, healthy potato or latent virus, and others of the same type. Typical disease, simple mosaic.

Group 2.—Viruses of the F type (tuber blotch virus), which produce characteristic brown or purple-fringed spots on *Solanum nodiflorum* and *Capsicum annuum* followed by clear mosaic on the latter; are carried symptomlessly by tobacco and *Datura Stramonium*; produce typically bright yellow spotting of the lower leaves of potatoes, which is intensified by the presence of

[1] Recent work by Dykstra (Phytopath., 25: 1115–1116, 1935) furnishes evidence that the top-necrosis virus B latent in many potato varieties is not an X virus because it infects the U.S.D.A. potato seedling 41956 which is said to be resistant to X. Little is known of the properties of the virus, but it possibly represents a fourth type of potato mosaic virus.

virus A; cause hereditary parenchyma necrosis in the tubers of many potato varieties; are transmitted by *Myzus persicae* in certain cases and conditions; and fail to pass an L 3 filter candle.

> *Virus F of Clinch, Loughnane, and Murphy, pseudonetnecrosis virus, Monocraat virus, virus G (or aucuba mosaic virus), and possibly calico virus. Typical diseases, yellow or aucuba mosaics and characteristic tuber parenchyma necrosis in many varieties.*

Group 3.—Viruses of the Y type, which are readily transmissible by *Myzus persicae*; produce green vein-banding in tobacco; are non-inoculable to *Datura Stramonium*; non-filterable through L 3 candles; and typically cause acropetal necrosis in certain potato varieties, although this feature varies in the case of virus A.

> *Virus Y of Smith, virus A of Murphy, vein-banding virus. Typical diseases, veinal mosaics, leaf-drop streak, rugose mosaic caused by (vein-banding virus + X), and crinkle caused by (A + X).*

All the viruses enumerated are not necessarily distinct, and it is probable that in any one of these groups the inter-relationships of the individual members may be closer in some cases than in others. Salaman (26) and Bawden (2) have shown that several of the members of the X group "protect" one against the other, and Chester (3) and Spooner and Bawden (30) have shown in addition that the serological reactions of certain members of the X group are identical. According to present views, these viruses are, therefore, shown to be very closely related. The serological and immunological reactions of all the viruses of the other mosaic groups have not yet been determined. Possibly they may not all be so closely connected, in which case the formation of sub-groups in a system such as this would be necessary.

As virus F is frequently carried, it is necessary to ensure its absence in routine potato testing. This can be done by relying on Epicure, on which pronounced primary symptoms occur, rather than Arran Crest, in the test varieties (as in Bawden's system (29, p. 324)), or reliance can be placed on necrosis in the tubers of President.

The economic importance of the tuber-spotting viruses is believed to be considerable. Apart from the observations made on them in Holland and Ireland, there have been a number of records recently, particularly in Italy, of tuber-spotting, sometimes to the extent of 70 per cent. of the crop, especially in the variety Böhm's Allerfrüheste Gelbe imported from Germany (6, 9, 17, 25). The infection passed from the seed-piece to the resulting tubers without foliage symptoms, and was considered to be Quanjer's pseudonetnecrosis. Preliminary experiments at Glasnevin in 1935 showed that the Monocraat virus caused numerous small lesions throughout the flesh of this variety, but the

plants were by no means virus-free to begin with, and the experiment is being repeated with more healthy stock.

Summary.

A comparative account is given of the symptoms and properties of the virus of aucuba mosaic of potato, a virus isolated out of interveinal mosaic of potato, and referred to as the tuber blotch virus, and a latent virus in the Dutch variety Monocraat supplied by Professor Quanjer.

The three viruses are readily transmissible by sap to potato and a number of other solanaceous plants.

The aucuba virus causes yellow mottle or variegation on the lower or middle leaves of the fourteen potato varieties tried, and necrosis of the cortex and pith of the tubers of seven of them. The tuber blotch and Monocraat viruses cause a similar but inconspicuous yellow mottle of the lower leaves (preceded in certain cases by primary symptoms of rusty wilt), or no symptoms, in the twenty-five varieties tried, and similar necrosis in the tubers of at least thirteen of them. The two latter viruses cause practically identical symptoms on potato, but those of aucuba mosaic are different.

The three viruses produce identical symptoms, consisting of spots with brown or purple borders, followed by purple rust and mosaic in *Solanum nodiflorum* and *Capsicum annuum*, which are diagnostic.

The three viruses are readily inoculable to tobacco, *Datura Stramonium*, and *Petunia*, and react similarly, producing no symptoms. The aucuba mosaic virus is differentiated from the others, however, by causing symptoms in tomato and *Solanum Dulcamara*.

The three viruses are similar in their physical properties, including filterability, thermal death-point, and longevity *in vitro*.

The tuber blotch virus has been successfully transmitted by *Myzus persicae*, but only in the presence of virus A. Attempts to transmit the other viruses are in progress.

The tuber blotch and Monocraat viruses are identical, and they probably correspond to the virus underlying pseudonetnecrosis. The aucuba virus is a related but distinct form, and the calico virus is probably related also.

It is proposed to designate the tuber blotch virus as virus F, with the Monocraat virus as a synonym, and the virus of aucuba mosaic as virus G, following the alphabetical system in use at present.

These viruses form, with other similar ones, a natural group with distinctive properties.

It is considered that the potato mosaics can be classified in three broad groups, of which the types are—(1) virus X of Smith, (2) virus F of Clinch, Loughnane and Murphy, and (3) virus Y of Smith.

EXPLANATION OF PLATES.

Plate 10.

Fig. 1.—Potato plant, var. President, grafted with scion from *Datura Stramonium* which had been inoculated with the aucuba mosaic virus. The stock shows a yellow mottle on the lower leaves, but the *Datura* scion is symptomless.

Fig. 2.—Whole tuber (2A) from President plant infected with aucuba mosaic, and (2B) cut tuber showing necrosis in the cortex. (The necrosis frequently occurs in the pith also.)

Fig. 3.—Upper leaf from Irish Chieftain potato plant infected with the aucuba mosaic virus + virus A. Note brilliant variegation (which extended to top of plant) due to the combination of viruses.

Fig. 4.—Leaf from President potato plant infected with the tuber blotch virus + virus A. Note brilliant yellow variegation resulting from the combination of viruses.

Plate 11.

Fig. 5.—Lower leaf of Monocraat potato plant showing yellow mottle due to the Monocraat virus.

Fig. 6.—Primary symptoms of rusty wilt caused by the Monocraat virus on lower leaf of Dunbar Yeoman potato plant. The secondary symptoms are yellow mottle, as in Fig. 7.

Fig. 7.—Primary symptoms of yellow mottle caused by the tuber blotch virus on lower leaf of Dunbar Yeoman.

Fig. 8.—Whole tuber (8A) and cut tuber (8B) of President infected with the tuber blotch virus. Note necrosis in cortex and pith.

Plate 12.

Fig. 9.—Leaves from pepper plant infected with the aucuba mosaic virus showing local lesions (left) and secondary symptoms.

Fig. 10.—Local lesions on leaf of *Solanum nodiflorum* inoculated with the aucuba mosaic virus.

Fig. 11.—Secondary symptoms of tuber blotch (left) and aucuba mosaic (right) viruses in *Solanum nodiflorum.*

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FIG. 1.

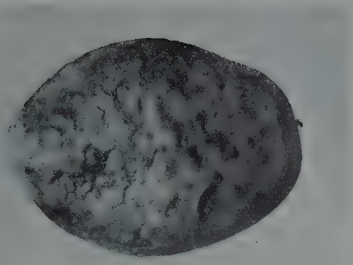

FIG. 2 A.

FIG. 2 B.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

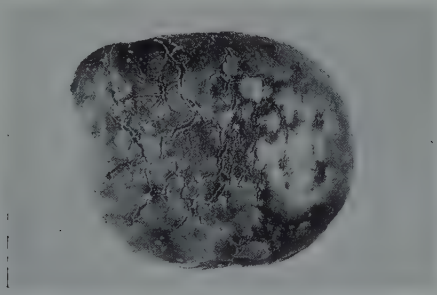

FIG. 8 A.

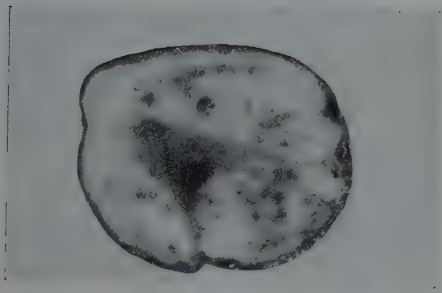

FIG. 8 B.

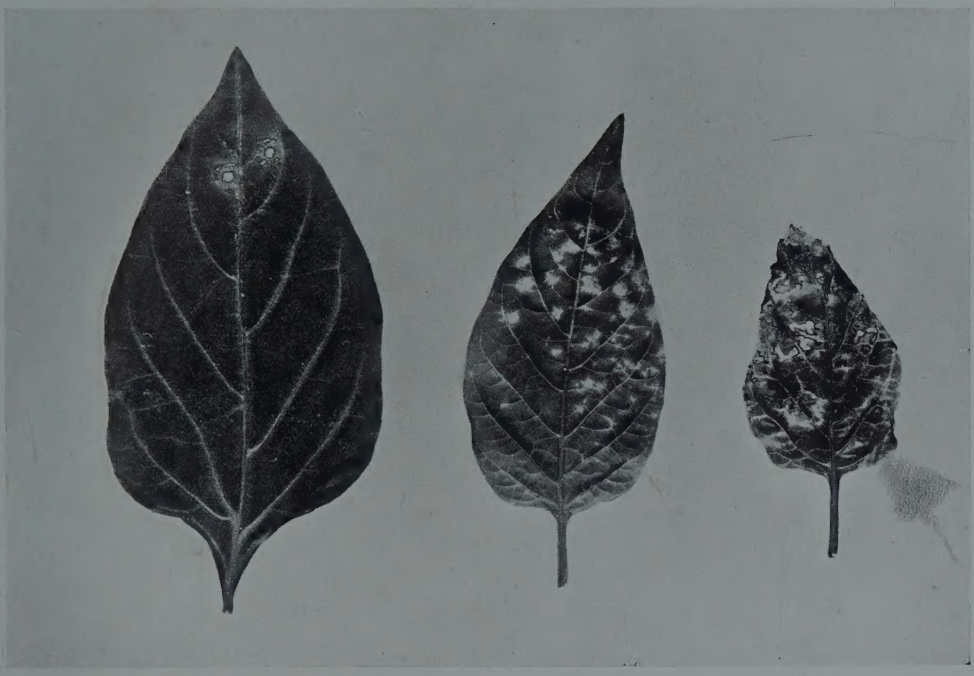

FIG. 9.

FIG. 10.

FIG. 11.

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